SIR JOHN ERICHSEN DEAD.

One of the Most Prominent of English Surgeons.

LONDON, September 24.—Sir John Eric Erichsen, who was made a Baronet in 1895, is dead.

Sir John Eric Erichsen was born in 1818, and was best known for several works on physiology and surgery—notably "The Science and Art of Surgery," which has been translated into German, Spanish, Italian and even Chinese. Sir John was the unsuccessful Liberal candidate for the Universities of Edinburgh and St. Andrews in 1885. He was formerly president of the Royal College of Surgeons and was a Fellow of the Royal Society, the University of New York, the American Surgical Association and other scientific institutions. He was Surgeon-Extraordinary to the Queen, and was president of the University College, London.

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THE SCIENCE AND ART

OF

SURGERY.

"*They be the best* Chirurgeons *which being learned incline to the traditions of experience, or being empirics incline to the methods of learning.*"

BACON on *Learning.*

THE

SCIENCE AND ART

OF

SURGERY.

A Treatise on Surgical Injuries, Diseases, and Operations.

BY

SIR JOHN ERIC ERICHSEN, BT., F.R.S., LL.D. (EDIN.)

HON. M.CH. R. UNIV. IRELAND, AND F.R.C.S. (IRELAND).

SURGEON EXTRAORDINARY TO HER MAJESTY THE QUEEN.

PRESIDENT OF UNIVERSITY COLLEGE, LONDON.

FELLOW AND EX-PRESIDENT OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND.

EMERITUS PROFESSOR OF SURGERY, UNIVERSITY COLLEGE. CONSULTING SURGEON, UNIVERSITY COLLEGE HOSPITAL.

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TENTH EDITION.

REVISED BY THE LATE

MARCUS BECK, M.S. & M.B. (LOND.), F.R.C.S.

SURGEON TO UNIVERSITY COLLEGE HOSPITAL; AND PROFESSOR OF SURGERY IN UNIVERSITY COLLEGE, LONDON.

AND BY

RAYMOND JOHNSON, M.B. & B.S. (LOND.), F.R.C.S.

ASSISTANT SURGEON TO UNIVERSITY COLLEGE HOSPITAL AND TO THE VICTORIA HOSPITAL FOR CHILDREN; HUNTERIAN PROFESSOR ROYAL COLLEGE OF SURGEONS OF ENGLAND, 1894.

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PREFACE

TO THE TENTH EDITION.

The period that has elapsed since the Ninth Edition of the "Science and Art of Surgery" was published has been marked by many important advances in the Pathology as well as in the Practice of Surgery. Due prominence has been given in this Edition to that which is both new and important. No pains have been spared to bring the whole work up to the standard of the most advanced modern Surgery, and this has been done without any very appreciable increase in its bulk.

The premature death of Professor Marcus Beck—*multis ille bonis flebilis occidit, nulli flebilior quam mihi*—was a great loss not only to the Profession of which he was so distinguished a member, but to "The Science and Art of Surgery" of which he had been so long the able Editor. Learned without being a pedant; scientific and yet practical; a master of the Art but not a slave to the details of Surgery, he was specially well fitted for the task of revising a work such as this. Fortunately, he had left the New Edition in a forward state—nearly one-third of the First Volume being ready for the Press at the time of his death, and much valuable material being collected for the remainder. Mr. Raymond Johnson, his pupil, friend and assistant, was requested to complete the Revision of the Work, to bring it up to date and to carry it through the Press. This, the Author feels confident, he has done in a manner which will fully maintain the character that the work had acquired under the Editorship of his predecessor.

Mr. Meredith has again kindly undertaken the Revision of the

Chapter on Gynæcological Surgery; and Mr. C. Louis Taylor has given valuable assistance in carrying the work through the Press.

The Author is also deeply indebted to Mr. T. W. P. Lawrence, Curator of the Museum of University College, for the care which he has taken in supervising generally the Illustrations of the book, and for many new Figures from his pencil.

Several of the old wood-cuts have been cancelled and re-drawn, and many new ones have been added. In the few instances in which a wood-cut has been copied from another work, the name of the author of the work from which it is taken has been appended to it. When no such acknowledgment is made, the figure is original, belongs exclusively to this work, and except in the case of diagrams has been drawn from nature. The Author may be excused for laying stress on these points, as many of his illustrations have been copied into other works on Surgery without any acknowledgment of the source whence they have been taken.

The Author feels that a responsibility, weighty in proportion to the very extent of the wide diffusion of his instruction, is incurred by him who takes upon himself the task of teaching others that Science which underlies the Art, and that Art, the exercise of which constitutes the application to Practice of a great branch of Medical Knowledge, which more directly than any other Department of Medicine involves the physical well-being, and more immediately affects the life of those on whom it is exercised.

It is not sufficient that the teaching of a Scientific Art, such as Surgery, should be sound in those General Laws that constitute its Principles. It must also be accurate in those minute details that are necessary to its successful Practice, and, above all, just in its estimate of the labours of others.

A Teacher of Surgery, who seeks to give a true and impartial view of the subject of his tuition, is placed in much the same position as a Judge who is summing up a great cause.

He must endeavour to divest himself of the trammels of the Schools—to free himself alike from the partisanship of individual bias and from the prejudice of professional antagonism.

He must lay down clearly the broad General Principles on which the Case rests; set forth its facts in an orderly and succinct manner, draw those deductions which legitimately flow therefrom, and guide his Pupils to arrive at just conclusions by the light of his own more matured and extended experience.

Throughout the Work it has been the object of the Author to place before the Student and Practitioner the Science and Art of Surgery—not as consisting, merely, in the observation of such Injuries, Diseases, and Malformations as are met with in Surgical Practice, or in the dexterous application of manual or operative means for their relief; but as demanding an exercise of general medical knowledge, and a thorough acquaintance with all those conditions, whether intrinsic to the patient, or surrounding him, that favour or prevent his restoration to health. The remarks in the earlier part of the First Chapter will, it is trusted, sufficiently indicate to the Student what is required of him in order that he may become a successful Practitioner of Surgery.

In every instance an endeavour has been made to give as full and clear a description of Symptoms, Pathology, Diagnosis, and Treatment, as the importance of each demands, and the present state of Surgical Knowledge permits.

The various new Operations practised in modern Surgery have been carefully described, the difficulties and dangers attending their performance pointed out, and the cases requiring them detailed.

The paramount importance of Surgical Hygiene, both general and local, has led to special attention being paid to it in the Chapters on Operations, Wounds, and Septic Diseases.

With respect to Diagnosis it may be remarked that, as accuracy in this branch is an all-important requisite for success in Treatment,

not only have the signs and symptoms by which the injury or disease under consideration may be recognized been described in each case, but care has been taken, even at the risk of occasional repetition, to point out the several conditions with which it may be confounded, and the means of distinguishing it from each of them.

More than forty years have passed since the First Edition of this Work appeared. During this lengthened period it has met with no inconsiderable favour in this and in other countries. Nearly forty thousand copies have issued from the Press in this country. Successive Editions have been reprinted in the United States of America, and it has been translated into several of the European Languages. The Author cannot but hope that the present Edition in its amended form will be found deserving of the continued confidence of the Surgical Profession at home and abroad.

JOHN ERIC ERICHSEN.

LONDON, 1895.

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DIVISION FIRST.

FIRST PRINCIPLES.

CHAPTER I.

GENERAL CONSIDERATIONS ON OPERATIONS.

A SURGICAL OPERATION is a Mechanical Procedure undertaken for the remedy of Deformity, congenital or acquired, or for the relief of those effects of Injury or Disease that are not curable by constitutional or ordinary local treatment, or in which such treatment would be too slow in effecting the desired result.

A *Surgical Operation* may be necessary for the following objects:

1. *Remedying or Removing Congenital Defects and Malformations:* as Hare-lip, Club-foot, or Supernumerary Fingers or Toes.

2. *Remedying Acquired Defects and Deformities:* as in the Closure of Fistulæ, the Restoration of Lost Parts, and the Correction of Distortions of the Limbs.

3. The *Removal of Foreign Substances* from the Body: as in the Extraction of a Bullet or a Calculus.

4. The *Repair of the Effects of Injuries:* as in the treatment of certain Fractures and Dislocations.

5. The *Removal of Parts* that have been so disorganised by the effects of *Injury* that their continued connection with the rest of the body would be a source of danger: as in Amputation for Frost-bite or Mangled Limbs.

6. The *Removal of Diseased Structures* that interfere with the utility of an organ or part: as in the Extraction of a Cataract.

7. The *Removal of Diseased Structures* that seriously inconvenience the patient or that remotely threaten life: as in the Extirpation of Tumours, Simple or Malignant.

8. *Rescuing a Patient from Immediate and Inevitable Death:* as in Tying a Bleeding Artery, Opening the Windpipe in Laryngeal Obstructions, Relieving an Over-distended Bladder, or Dividing the Stricture in Strangulated Hernia.

Operative Surgery, like every other art, can be carried only to a certain point of excellence. An art may be modified—it may be improved—but it cannot be perfected beyond certain limits. And so it is, and indeed must be,

with that of Surgery. There cannot always be fresh fields for conquest by the knife. There must be portions of the human frame that will ever remain sacred from its intrusion—at least, in the Surgeon's hand.

When we reflect that every large artery in the body up to the aorta itself has been ligatured, that each of the six large articulations and many of the bones have been resected, that amputation at the shoulder or hip is a matter of ordinary occurrence, that tumours have been excised from every region of the body, that the larynx, the spleen, the kidney, the pregnant uterus, and even portions of the liver, stomach and brain have been successfully removed, we can scarcely doubt that the limits of Surgery have been nearly reached. It is possible that they may even have been occasionally exceeded, for some of the operations recently performed for the removal of important organs have been far from successful, and it has yet to be determined whether they are surgical triumphs or mere operative audacities. The Surgeon of the future can scarcely hope to invent new operations ; he must be content to modify and perfect those that have been devised by the genius and skill of his predecessors.

But if the mechanical Art of Surgery has attained to so high a degree of perfection that we can scarcely hope for much further progress in that direction, the case is widely different with the Science. Here truly, so far from having approached the limits of our subject, we are but as yet on the threshold. For whether we regard the science of Surgery in its relation to the essential nature, the pathology and the diagnosis of surgical diseases and injuries, or whether we consider it in reference to all those circumstances which, independently of the mechanical skill of the operator, influence for good or for ill the results of his procedures, we have a field before us the extent of which it is difficult yet to estimate.

Until a comparatively recent period, although the results of minor operations were generally satisfactory, the success attending those graver procedures, by which the life of the patient is directly imperilled, bore no relation to the perfection in the execution of the operation. At this time the highly polished Art of Surgery far outshone its Science. The rapid advance of scientific knowledge, however, during the last quarter of a century, has not been without its influence on the Art of Surgery. The history of Surgery is characterised by great discoveries, forming landmarks which stand out prominently as starting-points from which new departures have been taken in its Art. Such were the revival of the use of the ligature in the sixteenth century, the discovery of the circulation of the blood, the invention of the tourniquet in the seventeenth, and the introduction of the Hunterian operation for Aneurism in the eighteenth. The nineteenth century will ever be conspicuous as that in which the inestimable boon of Anæsthetics was conferred upon mankind ; by means of them not only has pain in Surgery been abolished, but the extent of its operative department immensely enlarged, for they enable the Surgeon to perform, and the patient to undergo procedures, the agony of which would otherwise have been beyond the power of human endurance. Of no less importance has been the discovery of the relation of micro-organisms to putrefaction and to infective diseases. The so-called "germ-theory of putrefaction" was first established as a scientific truth by the researches of Pasteur, but it is undoubtedly to Lister that Surgery owes the application of this theory to practice. The scientific employment of antiseptics as introduced by

him, and modified subsequently by himself and numerous other Surgeons, has probably saved more lives than any single discovery since vaccination. However the details of the *Antiseptic Method* may be varied in the course of time, the principle which underlies it and on which its details are founded cannot change, for it is based upon facts now beyond dispute. The principle may be briefly described as follows. The vast majority of unhealthy inflammations in wounds and the constitutional affections which arise from them, are due to the presence of microscopic organisms which have gained admission directly from without. These organisms may enter the wound from the air, but are more commonly carried by water, or by the Surgeon's hands or instruments. Experimental investigation has shown that they are destroyed by numerous chemical substances known as antiseptics. The antiseptic method of treatment consists, therefore, in preventing the entrance of these organisms by the use of antiseptic solutions, for washing the wound, or sponges ; in disinfecting with similar solutions all instruments and the Surgeon's hands, and the wound itself, if it have been exposed to infection, as must necessarily be the case in all accidental injuries. The wound being thus freed from all living organisms, is protected from subsequent infection by the application of a dressing impregnated with some antiseptic substance. It is an important feature of the Antiseptic Method, that after the wound has been once disinfected, the antiseptic shall not be allowed to come in contact with the raw surface, as all chemical antiseptics are more or less powerfully irritating. This distinguishes the true Antiseptic Method from the old-fashioned plan of using disinfectants. The object of the Antiseptic Method is absolutely to prevent putrefaction or infection, and at the same time to irritate the raw surfaces of the wound as little as possible by the antiseptic. In every detail of practice the Surgeon must be guided by the theory. Antiseptics have been used in Surgery from time immemorial, but the results obtained were unsatisfactory till their employment was directed by more accurate knowledge of the causes of putrefaction and of infection. Their scientific use has revolutionised modern Surgery, and has done almost as much to extend the field of operative surgery as the introduction of Anæsthetics.

A scarcely less noticeable feature of this epoch has been the application of the rules of hygiene to the construction and management of hospitals, by which the general health of the patients has been much benefited and the mortality reduced.

Success in the results is, after all, the thing to aim at, and no amount of manual dexterity can compensate for its want. Manual dexterity is necessarily of the first advantage in the performance of any operation, and the Surgeon should diligently endeavour to acquire the art of using his instruments with neatness and certainty ; but it would be a fatal error to suppose that this is the only or indeed the chief requirement on the part of an operator. Manual dexterity must not be mistaken for surgical skill ; and, desirable as it may be to be able to remove a limb, or to cut out a stone, with rapidity,—important, in a word, as it is to become a dexterous operator—it is of far greater importance to become a successful Surgeon. The object of every operation is the removal of some condition that either threatens life, or interferes with the comfort or utility of existence ; and the more safely as well as certainly a Surgeon can accomplish this object, the better will he do his duty to his patients, and the more successful will he be in his practice. Success then, in

the result of an operation is the thing to aim at, and to this, dexterity and rapidity in operating are in a high degree conducive; but the Surgeon must also be prepared to deal with complex problems, the solution of which can only be afforded by an intimate general acquaintance with the Science of Surgery and of Medicine. The Diagnosis of the local disease, and of the extent of its connections, must be made; lurking visceral affections must be detected and, if possible, removed. The Constitution of the patient must be prepared; he must, as far as possible, be placed in those hygienic conditions which are most favourable to recovery; the best time for the performance of the operation must be seized; and, after its completion, the general health must be attended to in such a way as shall best carry the patient through the difficulties he has to encounter, and any sequelæ or complications that arise must be subjected to appropriate treatment. These, as well as the simple performance of the operation, are the duties of the Surgeon; and on the manner in which they are performed, as much as, or perhaps even more than, on the mere manual dexterity displayed in the operation itself, will the fate of the patient depend. Success in Operative Surgery mainly depends on two conditions: 1. The selection of proper cases; that is to say, of cases in which alone an operation will probably be followed by a successful result; and 2. the avoidance or the combating of those deleterious influences, hygienic and others, to which a patient may be exposed after an operation, and which may directly mar its success.

The practice of operating in notoriously hopeless cases, with the view of giving the patient what is called a "last chance," is much to be deprecated. By operating in such circumstances, especially in malignant diseases, much discredit has resulted to Surgery; for in a great number of instances the patient's death is hastened by the procedure, which, instead of giving him a last chance, causes him only to be despatched sooner than he would otherwise have been.

It may truly be said that a great surgical operation, in its conception, its performance, and its completion, tests the Surgeon's medical knowledge as much and in as varied a manner as it taxes his manual skill; and that, taken as a whole, it is the highest development of the medical art.

CONDITIONS INFLUENCING THE SUCCESS OF OPERATIONS.

The circumstances that mainly influence the result of an operation, so far as the recovery of the patient is concerned, may be arranged under three heads:—1. Those that are connected with the *State of the Patient's General Health* before and at the time of its performance; 2. The *Hygienic Conditions* by which he is surrounded after it is done; and 3. The *Special Dangers* connected with the operation itself.

1. All other circumstances being alike, the condition of a patient that principally determines the result of an operation is the **State of the General Health.** Sometimes we see a patient carried off by disease supervening on some trifling operation, (such as the removal of a small tumour,) which in itself ought in no way to endanger life, were it not that the patient's constitution was at the time of its performance in so unhealthy a state that the slightest exciting cause has been sufficient to call the fatal disease into activity. So, also, it is no uncommon experience to see one patient sink after an

operation most dexterously performed, owing to some constitutional condition that predisposes to diffuse inflammations; whilst another may possibly make the most remarkable and rapid recovery after he has been mutilated with but little skill. Independently of actual organic disease of the viscera, of which I shall hereafter speak, there are certain conditions of the nervous system, the circulation, and the general physical state that exercise an injurious influence. Thus, persons of an irritable and anxious mind do not bear operations so well as those of a more tranquil mental constitution. Those also of a feeble and irritable habit of body, especially nervous and hysterical women, with but little strength of circulation, cannot bear up against severe surgical procedures, and are apt to become depressed and to sink without rallying. Persons who are overloaded with fat are not good subjects for surgical operations. In them the circulation is usually feeble; the wound heals slowly, and is apt to slough; and general or local infective processes readily occur. Short of actual structural disease of important organs, as the lungs, heart, or kidneys, I know no condition more unfavourable to success after operations than premature or excessive obesity.

Operations on very old people, if severe and attended by much shock, are commonly fatal; amputations after the age of seventy are rarely successful.

Patients with a high temperature should never be operated on except for the relief of the condition causing the fever, such as the accumulation of pus, or rapidly spreading gangrenous inflammation, or in one of those four great surgical emergencies that under all circumstances demand immediate operation; viz.: 1, dangerous hæmorrhage; 2, impending asphyxia; 3, strangulated hernia and intestinal obstruction; and 4, over-distended bladder. The urgency of these conditions, which may be termed the four classes of primary surgical urgency, overrides all other considerations.

An individual with a constitution unimpaired by excesses of any kind, whose habits have been temperate, whose diet has been sufficient and of good quality, whose mind has never been over-strained by the anxieties of business or the labours of a professional life, and whose existence has been spent in rural occupations and in the pure air of the country, is necessarily placed in a far more favourable position to bear the effects of any mutilation, whether it be the result of accident, or inflicted by the Surgeon's knife, than the man whose physical powers are worn out by active and unceasing business avocations or professional work, whose nervous system is exhausted by his anxious labours; and infinitely more so than the poor inhabitant of a large and densely peopled town, who has from earliest childhood inhaled an impure and fœtid atmosphere, whose scanty diet has consisted of the refuse of the shops, or the semi-decomposed offal of the stalls, and whose nervous system has been irritated and at the same time exhausted in the daily struggle for a precarious livelihood, or over-stimulated by habitual excesses in strong drinks. Though individuals with such different antecedents be placed under exactly the same hygienic circumstances *after* the performance of an operation, yet the results will probably be very dissimilar, influenced as they must be by their past rather than by their present condition.

Besides the general state of the patient's health, the *Condition of Important Organs* must be taken into consideration before an operation is decided on. The state of the *Heart* should be carefully looked to. Valvular disease, if early or slight, need not be an obstacle to most operations, even to those of

expediency; but fatty degeneration, as indicated by its feeble action, by irregularity and want of power in the pulse, by breathlessness, and by a distinctly marked arcus senilis, should make the Surgeon cautious about undertaking any operation attended with much loss of blood or shock. Such a condition of heart is liable to occasion great depression of strength, syncope, and death—often sudden—some days after the operation. In cases of chronic disease that it would otherwise be proper to submit to operation, this condition of the heart becomes a serious obstacle, but it need not be a bar to operation in acute cases that would be speedily fatal if left to themselves, and certainly not in one of the four conditions of primary surgical urgency.

Tubercular Disease of the *Lungs*, when active or advanced, is prejudicial to the success of an operation; but under certain circumstances, as will be explained when speaking of diseases of the joints and fistula in ano, an operation is justifiable, even though the patient be consumptive.

If the *Liver* be affected by cirrhosis, and more especially if any symptoms of ascites have supervened, no operation but for the relief of disease that instantly threatens life should be undertaken. Amyloid degeneration does not counter-indicate an operation if, by that means the cause of the condition can be removed, as in some cases of chronic joint or bone disease.

Perhaps, however, the affection that militates more than any other against the success of an operation, is disease of the *Kidneys*, with albuminuria; in this condition the local inflammation that is set up is apt to assume a diffuse and sloughing form, and this is especially the case in all operations about the pelvic and genito-urinary organs.

Saccharine Diabetes is another condition which seriously endangers the success of any operation. In acute diabetes no operation should ever be undertaken but for the immediate preservation of life. The tendency to the occurrence of carbuncle and spontaneous gangrene is a well-known feature of the disease, and this shows itself after an operation by want of repair, or sloughing of the surfaces of the wound. The feeble tissues readily become infected by septic organisms, which set up widely-spreading diffuse inflammation followed by septicæmia and death.

In chronic diabetes of middle life, when the patient is well nourished and often gouty, operations may be undertaken with a fair prospect of success. The conditions indicating the possibility of operating are, first, the amount of sugar should not exceed 2 per cent., and should be easily reducible below this by the administration of opium and proper diet; secondly, the general symptoms, thirst, hunger, loss of flesh, &c., must not be marked, and the "knee-jerk," which is often lost in diabetes, should be present: and thirdly, the proposed operation must be one in which asepsis can be ensured with certainty. Even in such selected cases death will frequently follow a severe operation, either from exhaustion or from the supervention of coma. The patient should be kept gently under the influence of opium till the wound is healed, and the diet should, as far as possible, be that ordinarily employed in the treatment of diabetes, all starchy and saccharine matter being excluded. Should the wound become septic, the patient's chance of recovery is small, even from a comparatively slight operation.

Albuminuria and diabetes form, in fact, such serious complications, that no operation, even the most trivial, should be undertaken, except in cases of

emergency, without previously examining the urine both for albumen and sugar.

The *contamination of the patient's system by Malignant Disease* must always prevent our operating; as, if this has taken place, the disease cannot be completely removed. And, lastly, no operation, save for the purpose of rescuing the patient from impending death, should ever be performed whilst he is labouring under *Pyæmia, Septicæmia, Erysipelas, Phlebitis, or any Diffuse Inflammation;* and even during the epidemic prevalence of these affections, operations that are not of immediate necessity should be postponed until a more favourable season.

2. **The Hygienic Conditions** to which a patient is exposed both before and after an operation, will most materially influence its results. These conditions are of two kinds:—1. As regards the diet of the patient, and 2. As concerns his exposure to a vitiated atmosphere contaminated by the emanations from the sick and wounded, such as is commonly met with in the wards of an over-crowded or ill-constructed hospital.*

The proper regulation of the patient's *Diet* before and after an operation is of great consequence. On this point it is impossible to lay down any very definite rule, as much depends not only on the patient's previous habits of life, but on the nature of the operation itself; and, as this subject will be discussed at the end of the Chapter, it need not detain us here. It is not often, however, that in civil practice the insufficient quantity or the bad quality of the patient's food, with which he is supplied *after* the performance, influences materially the result of an operation. But in military and naval practice in time of war the case is far different. The soldier or the sailor on active service is often exposed to serious injuries that necessitate important operations at a time when he has already been weakened by scurvy, dysentery, or some similar affection, resulting from the deficient quantity and the unwholesome character of his food. After the operation his only available nutriment may be of the coarsest character, possibly salted, and imperfectly cooked. In such circumstances, and in the absence of efficient antiseptic treatment which must often be unavoidable in war, wounds do not heal, or they assume a peculiar gangrenous character; and the patient dies from septicæmia or pyæmia, or from profuse diarrhœa with ulceration of the intestines. The mortality of operations becomes enormously increased; and thousands of deaths which have occurred in wars between the most civilised nations and the best appointed armies have been due to these causes.

The *Hygienic Conditions* to which the patient is subjected after an operation will necessarily vary greatly according to the locality in and the circumstances under which it is performed—whether it is done in a private house, where the patient may be isolated, freed from the chance of all contamination, and surrounded by every sanitary precaution; or in a hospital, where he may be exposed to emanations, possibly of a septic and infectious character, from other patients, where the building may be impregnated by the exhalations from generations of sick and injured, and where sanitary measures may be neutralised by the conditions generated by a vast assemblage of sick under one roof. Then, again, the circumstances in which a patient is placed after an operation for an accident of civil life are necessarily very different from those

* I would refer the reader who wishes to study this very important subject more deeply to my "*Lectures on Hospitalism and the Causes of Death after Operations.*" Longmans, 1874.

that surround one who is exposed to the peculiar perils that are necessarily connected with military hospitals and ambulances in time of war, and which will be more fully described in the chapter on Gunshot wounds.

In private practice, ill results may follow operations from three different causes, viz.: self-infection of the patient, in consequence of the retention of decomposing secretions in the wound; conveyance of infection by the Surgeon; and general faulty sanitary arrangements. In hospital practice these different sources of danger must necessarily exist to the same if not to a greater extent than in private. In hospital, however, just as in private practice, these particular dangers are all preventable, and disease of a septic character ought not to be allowed to generate itself through their medium. The frequency of such an occurrence is in the direct ratio of the want of hygienic attention bestowed upon the patient.

The air of large towns in which the majority of hospitals must necessarily be situated is more or less loaded with impurities. The normal ·4 parts per 1,000 of carbonic acid gas is always exceeded, the amount sometimes reaching as high as ·5 or ·55, and there is moreover always a deficiency, often a total absence, of ozone. The amount of solid impurity is also very considerable. It has long been known that the atmosphere of inhabited houses and cities is loaded with minute particles of organic matter in suspension. Forty years ago Pouchet demonstrated the presence of starch granules in the dust deposited in a room. In 1861 Pasteur proved that the spores of some of the higher fungi are always to be found in the air of Paris. Tyndall also demonstrated by numerous experiments that a large proportion of the dust of the air is composed of organic matter. Further, microscopic observations by Pouchet and others showed that the air of inhabited rooms contains in suspension scaly epithelium, fragments of human hair and of cotton, linen and wool from the clothing. In hospital wards dried pus cells have also been found. All these impurities may be recognised without difficulty by microscopic examination of dust collected from the air. The experiments of Pasteur, Tyndall, Lister, and many others, further conclusively proved that the air contains minute solid particles, which act as ferments on dead organic matter, giving rise to such processes as the ordinary putrefaction of albuminoid substances, the lactic acid fermentation of milk, &c. That these particles are organised bodies, minute fungi or their spores, is now universally acknowledged. The number and nature of these organisms has been made the subject of daily observation by Miquel in the Observatory of Montsouris in Paris for many years past, and many interesting facts have been ascertained. His method of observation consists in drawing a measured quantity of air through a glass bulb filled with a solution of Liebig's extract of beef, which forms a suitable cultivating medium for microscopic fungi of almost all kinds. The fluid is, of course, freed from all living organisms before the experiment by prolonged boiling. If, after the admission of air, microscopic organisms appear in the fluid, he assumes that the quantity drawn through contained at least one microscopic fungus or its spore. Another mode of investigation which, in the hands of Koch and others, has given results confirmatory of those obtained by Miquel, is to expose to the air for a fixed time a measured surface of properly prepared nutrient gelatine freed from organisms by heat. The single organisms or spores which fall on the gelatine soon develop into colonies visible to the naked eye, and by

counting these the number of organisms that have been deposited can be ascertained, and their nature may be determined by subsequent microscopic examination. The general results of these observations have been to show that the number of micro-organisms in the pure air of a mountain top is very small, in fact they may be absent. In the air of an ordinary country place they are scarce, but always present; in the air of a city they become numerous, and the atmosphere of a surgical ward is often loaded with them. Thus, in the Observatory of Montsouris, which is situated in a park on the outskirts of Paris, the daily average was 75 organisms per cubic metre; in the Rue de Rivoli it was 750; in the low parts of Paris 850, and in a ward in the hospital of La Pitié it amounted to 11,100. In the wards of the hospital the number rapidly increased, when, owing to cold weather, the windows were closed. It may therefore be taken as proved that the air of hospitals, and inhabited houses generally, contains floating in it numerous organisms which are capable of growing in the discharges of wounds, and of establishing in them various fermentative changes, the products of which are more or less detrimental to the patient both locally and constitutionally. It is by no means necessary that the fermentative process thus induced should be the ordinary fœtid putrefaction; in fact the organisms which cause this are scarce in the air, being much more abundant in water; still, although there may be no smell, the fermentation set up in the discharges is not always innocuous.

The air of a surgical ward or sick room is vitiated by the patient, first, by the normal products of respiration and excretion from the lungs and skin; and secondly, in many cases by the emanations from wounds or sores. The first is unavoidable, the second is to a great extent under the control of the Surgeon.

An average adult man gives off per hour about ·6 cubic feet of carbonic acid gas, from 1 to 1½ ounces of water, and an undetermined quantity of organic matter. This organic matter is partly solid, consisting of epithelium and fatty matter from the skin and mouth, and partly a vapour given off from the lungs, the nature of which is somewhat uncertain. It is extremely offensive, and is so imperfectly diffusible that it is probably in great part molecular; it is nitrogenous and oxidisable, although but slowly. It is readily absorbed by damp walls or bedding, the most hygroscopic substances taking it up most readily. It is this substance that gives the fusty smell to an ill-ventilated room. Experiments have shown that it is highly poisonous, and this explains the fact that air fouled by respiration is much more deleterious than that vitiated by combustion or by the addition of pure carbonic acid gas. Parkes states that "allowing the fullest effect to all other agencies, there is no doubt that the breathing the vitiated atmosphere of respiration has a most injurious effect on the health. Persons soon become pale, and partially lose their appetite, and after a time decline in muscular strength and spirits. The aëration and nutrition of the blood seem to be interfered with, and the general tone of the system falls below par." Under such circumstances convalescence is prolonged; the reparative power is less, wounds tend to slough, and the patient is more readily affected by any local or general infective process to the poison of which he may be exposed.

The special contamination of a surgical ward may arise, first, from the presence in the atmosphere of the gaseous products of decomposition; secondly, from a great abundance of the organic particles which act as the

ferments in decomposition; thirdly, from the presence of dried particles of the discharges from wounds or sores; and, lastly, by the contagia of specific infective processes, whether general or local.

The gaseous products of decomposition, consisting of sulphuretted hydrogen, sulphide of ammonium, free ammonia, carburetted hydrogen, carbonic acid, and many others undoubtedly tend to aggravate the symptoms produced by the accumulation of the products of respiration; but it is impossible to separate the effects produced by the former from those of the latter, with which they must almost necessarily be complicated in a hospital ward. Parkes states that the putrefying animal matter which frequently accumulates about camps during war forms one of the principal causes of diarrhœa and dysentery; but it is only in military practice in which large numbers of wounded must occasionally be packed closely together and their wounds neglected for want of sufficient surgical assistance, that putrid discharges could accumulate to such an extent as to develop these diseases.

Secondly, the air of a ward containing many foul wounds has been shown to contain a great excess of organic matter, but it is impossible to separate the effects produced by it from those of foul air generally.

Thirdly, microscopic examination has demonstrated the presence of dried pus cells in the air of surgical wards in addition to the epithelium always met with in inhabited rooms. It has been supposed by some that these might possibly act as the material of contagion; that they may be the bearers of contagion cannot reasonably be doubted.

Lastly, the air of surgical wards is apt to be contaminated by the contagia of specific infective processes, such as hospital gangrene, erysipelas, pyæmia, &c. The exact nature of the contagium in all these diseases is not yet definitely ascertained. This much is certain, that the poison in all is particulate; it is never gaseous. Its activity can be destroyed by those chemical substances that we class as antiseptics. In the majority of cases the specific infective process commences in a wound, the discharges of which are in a putrid state; and those methods of treatment which are best calculated to prevent putrefaction also serve best to prevent the occurrence of infective processes, either local or general. It may now be said to be practically proved that all these unhealthy spreading inflammations are accompanied by the presence of microscopic organisms in the discharges, and often in the lymph spaces near the wound; and the view is now universally accepted that these micro-organisms are directly or indirectly the cause of the unhealthy processes, and that infection is brought about by the actual transference of some of these living particles from one patient to another. In the human subject erysipelas has been definitively proved to be caused by the invasion of the lymph-spaces of the skin by a specific fungus. Koch has shown that diseases closely resembling gangrenous erysipelas, septic infection, and pyæmia, as they occur in the human subject, can be artificially produced in animals; that each disease is accompanied by the presence of a distinct form of micro-organism, and that it can be transmitted from one animal to another by means of infinitesimal quantities of the blood or exudation fluids containing the characteristic organism. That the organisms or their spores retain their vitality after being dried has been clearly proved with regard to the somewhat analogous disease of anthrax in cattle. This disease is due to a rod-shaped organism, the bacillus anthracis, of such size that its life-

history can be accurately studied. It has been found that under certain conditions minute spores are developed in the bacillus, and that when this has taken place blood containing the virus may be dried and kept in that state for years without losing its virulence. In this state it is easily conceivable that it could be disseminated by the air. It is well known that the virus of vaccinia, small-pox, and scarlet fever equally resist the effects of drying.

Another fact of equal importance, which was first discovered by Pasteur and Toussaint, is that the virus of splenic fever and that of a peculiar form of septicæmia, common in fowls, known as chicken cholera, lose considerably in virulence if the organisms which form their essential part are cultivated under conditions which are not favourable to their growth. The converse, although equally well proved, is probably true also,—that a virus of low intensity increases in virulence if cultivated in a medium suited to its growth and development. Such a medium for the growth of pathogenic organisms is found in the feeble tissues and unhealthy sores of patients weakened by breathing the impure atmosphere of an over-crowded ward, and it is thus that infective processes of intense virulence may be developed. Our knowledge of the conditions under which the virus is developed in hospital gangrene and pyæmia, is still very far from perfect; but this much is certain, that they are essentially filth-diseases, and may, if the term be allowable, be manufactured in any hospital or house, however clean or well situated, by the accumulation within it of too large a number of patients suffering from wounds the discharges of which are in a state of decomposition. It is probable that the contagia of some of these diseases are destroyed by oxidation, especially if at the same time they are exposed to bright sunlight; but, be this as it may, it is evident that a want of free ventilation must lead to a concentration of such poisons as are disseminated by the air, and at the same time the patient's body will be rendered more susceptible to their influence as its vitality becomes lowered.

In the prevention of the effects of over-crowding we have to consider first the vitiation of the air by the natural processes of respiration and excretion; and, secondly, fouling of the atmosphere by the emanations from wounds and sores. The first of these causes of impurity is unavoidable, and it is only by providing sufficient air for each patient and changing it with sufficient frequency that its evil effects can be prevented. In determining the condition of the air of a room or ward the carbonic acid present is taken as the index of the degree of impurity, as it is easily estimated, while the determination of the organic matter is almost impossible. Parkes and De Chaumont give ·6 per 1000 volumes of total carbonic acid in the air as the limit of impurity allowable. Of this about ·2 is derived from respiration and the remainder is the normal quantity present in the atmosphere. In order to maintain the air at this standard an ordinary man requires to be supplied with 3000 cubic feet per hour. This is the minimum quantity of air that will suffice for the purpose, and it would evidently be unwise to trust to this. The rule, therefore, laid down is that at least 4000 cubic feet per hour must be provided. In order that this amount of air may be obtained without exposing the patient to draughts, a sufficient cubic space must be allowed for each patient, so that if the air be changed from three to four times per hour the requisite amount may be supplied. Under exceptional circumstances 1000 cubic feet per head might thus, with good ventilation, be made sufficient; but

no surgeon would be content with this if he could obtain more; as in civil practice he always can. The rule, therefore, laid down in the construction of hospitals is that each patient shall be allotted from 1500 to 2000 cubic feet of space, the larger space being required for infectious, or surgical cases. In order to maintain a proper degree of separation of the patients each must be allotted from 100 to 120 square feet of floor. The effective height of a ward for the purposes of ventilation does not exceed 12 feet. Not only, however, is *space* required, but change of air, by proper ventilation, is equally needful. Military experience has shown conclusively that churches form the worst possible hospitals, for in these buildings, although the cubic space per head is frequently enormous owing to the great height of the building, the floor area is comparatively small, and little provision is usually made for efficient change of air.

The second cause of vitiation of the air of a surgical ward—the emanations from wounds and sores—is more or less completely under the control of the surgeon. Wounds do not necessarily add to the impurity of the air of a ward; it was the decomposition of the discharges and the effluvia so developed that gave rise to the evil consequences formerly so familiar to most surgeons. Experience tends to show that if decomposition of the discharges be absolutely prevented, a case with a wound vitiates the air of a ward no more than one without; and in the present day, when the powers and properties of antiseptics are so well understood, there is never any excuse for a wound becoming a source of impurity to the surrounding air. Should decomposition be unavoidable, as it still is in many cases, it is easy to absorb the discharges in some antiseptic dressing, which will completely disinfect them as soon as they leave the patient's body. No surgeon doubts that an accumulation of putrid wounds in a ward gives rise to unhealthy processes, such as pyæmia, septicæmia, hospital gangrene, and the like. If such diseases do arise, most are agreed that the ward must be thoroughly disinfected before it can safely be used again. Surely it is more rational to commence the disinfection at the source of mischief—that is to say, the wound.

A sufficient cubic space, free ventilation, and clean wounds, are therefore the essentials of a healthy hospital. Attention to these three conditions, especially the last, has in many Continental hospitals reduced the death-rate to less than a quarter of what it was in former times. Care must be taken in attending to ventilation, that the free current of air is maintained both by night and day. It is from want of this precaution during night especially that much mischief often results. The importance of maintaining efficient ventilation during night, and the little danger to be apprehended from the admission of cold night air, were so forcibly pointed out by Miss Nightingale in [illegible] *Nursing*, and are now so universally admitted, that I [illegible] add the testimony of my experience to the truth [illegible] cold weather, also, there is so great a disposi[illegible] patients to shut up wards and rooms, that [illegible] contaminated; and hence it is that erys[illegible] during winter and early spring. The [illegible] being the cause of these; and no dou[illegible] windows and doors to be shut, so [illegible] panies that wind. It is impos[illegible] supply of pure air in less[illegible]

hospitals, but equally in private dwellings. The fact has often been observed in military practice, and the Franco-German War brought it into strong relief —that those wounded fare best who are treated in open huts or tents, whilst those who are placed in the apparently more favourable conditions afforded by regular houses become decimated by those scourges of military surgical practice, pyæmia and hospital gangrene. It is the difference in the hygienic arrangements in hospitals that, more than any other condition, influences the varying rate of mortality in different institutions; and it is obvious that, *cæteris paribus*, those patients will have the best prospect of recovery who are most scrupulously attended to in this respect; that no cases of operation should be placed in ill-ventilated wards, or in those that contain more than a certain percentage of patients suffering from wounds or sores, the discharges from which are unavoidably foul; and that the performance of operations in close and ill-ventilated rooms, or in houses situated in over-crowded neighbourhoods, should, as far as possible, be avoided. The faulty hygienic conditions that are still too frequently met with in hospitals, are alike a cruelty to the patient and an injustice to the Surgeon. The cruelty to the patient consists not only in exposing him to an increased chance of death—or, as it is commonly called, "to a higher rate of mortality" from septic diseases that are preventable, and that are the direct outcome of the defective hygienic arrangements of the institution—but in subjecting him to a prolonged and imperfect convalescence; either or both of which conditions may be taken as the measure of the neglect of sanitary arrangements in a hospital.

But want of attention to sanitary hospital arrangement is equally an injustice to the Surgeon. His reputation suffers by an increased rate of mortality amongst his patients from causes which, though preventable, are altogether beyond his control; an undue burden of anxiety, responsibility, and care is thrown upon him by the necessity under which he lies of waging a constant warfare against septic hospital influences.

Attention to hospital hygiene is by no means of so modern a date as many appear to suppose. The Surgeons of the last century paid great attention to it, and their success was proportionately great. Thus Alanson's success in amputations has never been surpassed, and rarely, if ever, equalled even with the aid of antiseptics and of every modern appliance. Writing in 1782 ("Alanson on Amputation and the After-treatment," London, 1782), he says (Preface, p. 15), that he amputated in thirty-five cases, such as promiscuously occurred in the Liverpool Infirmary, *without the loss of a single patient*. The symptomatic fever was slight, and there was not an instance of secondary hæmorrhage in the whole series. Alanson was a sanitary reformer in his day; and had his instructions been followed, thousands of lives would have been saved which have since his time been wantonly sacrificed by the neglect of hygienic measures. His advice is so practical that it deserves the attentive study of the modern Surgeon. He says: "The air in which the case is to be conducted is a point worthy of your greatest attention: if possible, the room should be spacious, and in an open, wholesome situation. It is well known that in hospitals which are situated in populous towns and are much crowded, the salutary influence of the air is so altered, that compound fractures and other important surgical cases prove peculiarly fatal, and that such fractures may almost certainly be cured in the country." . . .

"The operation of amputation done in the country, as above described, will

be followed almost certainly with a speedy cure ; there the consequent symptoms are trifling, nearly the whole internal surface of the wound unites by the first intention, the suppuration consequently is small." . . .

"Many hospitals are so tainted by unwholesome effluvia that they are rather a pest than a relief to the objects they contain." (Op. cit., pp. 89—92.)

Then follow sixteen distinct paragraphs or heads of the most useful sanitary advice, which "are humbly recommended to those who have the care of hospitals in want of such attention."

This code of regulations deserves careful study. In it Alanson advises :

That no ward should be inhabited for more than four months at a time ; that it be cleansed, whitewashed, and purified. That the "bed-stocks" be of iron ; the bedding frequently changed, and made of inexpensive materials so that it may easily be renewed ; and that when the weather admits, it be exposed to the open air for several hours a day. That dirty patients be stripped of their clothing before admission ; that they have a warm bath and then be clothed in dresses provided by the hospital. That the infected clothes be baked in a properly constructed oven. That newly admitted patients be put into clean, well-ventilated wards. That all incurable and infectious cases, and especially chronically ulcerated legs, be refused admission. That offensive gangrenous and putrid sores be placed in distinct rooms, and not suffered to infect a whole ward. That there should be particular rooms provided for patients who have undergone operations ; that they should be airy, never long inhabited, and afterwards cleansed and ventilated. That a hospital should never be crowded *on any account*, and always so large that a part may be uninhabited. That the windows be opened for a certain number of hours daily. And lastly, that every hospital should have a "house in the country," in other words, a "convalescent home," attached to it. Modern science has enabled us to determine the true nature of those conditions that lead to hospital infection, but sanitary practice has not as yet gone in advance of the admirable precepts laid down by Alanson more than a century ago.

The mortality arising from inattention to these various hygienic conditions, whether want of cleanliness in the wound or want of pure air in the ward, is not a necessity of the operation, but rises and falls according as the treatment of the wounds, or the circumstances in which the patient is placed, depart more or less widely from those conditions that are necessary to the maintenance of health. The frequency of the occurrence of erysipelas in an institution may be taken as an indication of neglect in its sanitary arrangements. Pyæmia and septicæmia as a rule indicate, in addition to general neglect, a want of cleanliness in the wounds, and reflect to a certain extent upon the Surgeon as well as the institution. These diseases are preventable, and ought to be prevented. Surely the first and most essential requisite of a hospital is that it be not a source of disease to its inmates—that those who are compelled to seek its aid shall not suffer from its effects.

The exposure of a patient after an operation to the *contagious emanations* of septic diseases from other sick or wounded patients, is attended with the most fatal consequences. Whenever it is practicable, every case of septic disease, such as pyæmia, erysipelas, inflamed lymphatics or veins, or hospital gangrene, should be rigorously excluded from the ward or room in which other patients with operation-wounds happen to be lying ; and, if possible, the same nurses, dressers, or surgeons should not be allowed to go from the infected to

the healthy, nor should the same appliances, dressings, or sponges be used for both. When this is not possible, the danger of infection may be greatly diminished by the free use of antiseptics to the wounds both of the infected and the healthy. Great care also should be taken in the purification of the bedding that has been used by patients suffering from septic disease; the blankets especially are apt to harbour infection long, and must be thoroughly disinfected by heat or by efficient chemical antiseptics.

3. The **Special Conditions directly excited by the Operation itself** predisposed to by the circumstances that we have just been considering, and commonly leading to a fatal result, of which they are the immediate occasion, are the following:—Shock, Exhaustion, Hæmorrhage, Gangrene, Tetanus, Pyæmia, Septicæmia, Erysipelas, and other Diffuse Inflammations. These causes of death are so various, and comprise so many distinct diseases, that I shall do little more here than mention them; referring the reader to the different chapters in the body of the work, in which each is specially treated.

The *Shock of an Operation* may prove fatal in various ways: from the severity of the mutilation, as in a case of double amputation; from the nervous centres being implicated, as in the removal from the face of large tumours that have connections with the base of the skull; from fear, or from the state of nervous depression into which the patient has previously fallen, causing him to feel the influence of an operation disproportionately to its severity. These various effects of shock have, however, been much lessened since anæsthetics have been generally administered in operative surgery. Anæsthesia, however, does not remove the physical impression produced on the system by a severe mutilation; hence the influence of a serious and prolonged operation is still manifested in the production of shock, of collapse, and of slow recovery, even though the patient have suffered no actual pain. Certain operations appear to exercise a peculiarly depressing effect on the nervous system, even though no pain be experienced. Thus, in castration, at the moment of the division of the spermatic cord, the pulse will sink markedly, even though the patient have been fully anæsthetised.

Exhaustion, without any tangible local or constitutional disease, is an occasional cause of death after severe operations; more particularly in delicate females, in feeble or debilitated subjects, in those who have lost much blood, or who have become weakened by protracted suppuration. A large number of the deaths formerly recorded as due to exhaustion were doubtless the effect of slow poisoning from the absorption of putrid matter from unclean and imperfectly drained wounds.

Hæmorrhage, if very copious, may be immediately fatal; or may increase the shock so that the patient cannot rally; or, by weakening him and lowering his vitality, it may render him more liable to be affected by unhealthy inflammations and septic processes, which frequently terminate in death. The danger from these secondary and indirect effects of excessive hæmorrhage is very great. Blood once lost is not easily replaced in advanced life, and at any period its excessive loss may permanently impair the constitution. It has been shown by experiment that animals previously weakened by loss of blood are more readily infected by pathogenic organisms than those in a normal condition, and this explains the fact that patients who have lost much blood make slow recoveries, often interrupted by intercurrent diseases which

may prove fatal. For these reasons hæmorrhage should, as much as possible, be prevented during the performance of an operation.

When hæmorrhage occurs within twenty-four hours of an operation, it usually proceeds from imperfect ligature of the vessels or from arteries bleeding after the commencement of reaction, which had not furnished blood whilst the patient was under the influence of the shock of operation. On recovery from anæsthesia also, it not unfrequently happens that arteries begin to spout, which yielded little or no blood whilst the patient was insensible. In these circumstances, hæmorrhage is of far less moment, and is less frequently fatal, than when it occurs at a later period, in consequence of some morbid condition of the wound, and frequently in association with local diffuse inflammation or general infective processes.

Gangrene from purely local conditions, as in a limb from excessive traumatic violence, or in a strangulated hernia in consequence of prolonged strangulation of the gut before operation, is an occasional cause of death.

Tetanus but rarely occasions death after operations in this country. When it does occur, it is more frequently after the lesser than after the greater operations that it develops itself.

Internal Inflammations of an acute character may carry off the patient after an operation in two ways. Inflammation of this kind may have existed antecedently to the operation, being the disease for which it is performed; and, being unchecked by the operation, may continue its course and destroy life. Thus, when a child dies after tracheotomy for diphtheria, death is not in general occasioned by the operation, but by the extension into the lungs of the disease for which it has been performed. Or the inflammation may be the consequence of the operation; as when peritonitis occurs after the operation for strangulated hernia, or meningitis after the skull has been trephined. But it is not by the action of any of these direct results that an operation usually proves fatal. In the great majority of instances, death is occasioned in a more indirect manner by the development of infective inflammations, to which a neglect of hygienic laws acts as a powerful predisposing cause.

Local and General Infective Diseases of septic origin, such as wound-diphtheria, hospital gangrene, erysipelas, pyæmia and septicæmia, were formerly frequent causes of death, more particularly in large towns. They were the dread of surgeons and the scourges of hospitals, and to them were probably due three-fourths of all deaths after operations. This proportion has, however, been greatly reduced by improved methods of treating wounds, and greater attention to the sanitary arrangements of our hospitals. In the production of these diseases, an impure blood, loaded with effete materials retained through habitual disregard of the ordinary rules of health or through defective elimination by the kidneys and skin, acts as a potent predisposing cause. In these circumstances, it is not the extent of the wound that determines the dangerous results. A mere breach of surface, however trivial, is sufficient to form a starting point for these morbid processes. The amputation of a toe may be as fatal as that of the thigh, or the removal of a small atheromatous cyst of the scalp as the ablation of the breast; the only additional danger essentially connected with the greater operation being the increased risk from shock and hæmorrhage.

PREPARATION FOR OPERATION.

The Surgeon, being convinced of the necessity of an operation, should fully lay before his patient the state of the case, in order to obtain his consent and that of his family. In the event of the patient refusing to submit, the Surgeon must be guided partly by the nature of the proposed operation; and partly by the state of the patient, and his capability of forming a correct judgment of his case. If the operation be one of expediency, merely for the relief of an infirmity or the removal of an ailment which does not directly jeopardise life, no Surgeon would think of undertaking it without the full consent of his patient. If, on the other hand, it be an operation that is necessary for the preservation of life, in which delay may be fatal, as in one of the four cases of surgical urgency, viz., dangerous hæmorrhage, asphyxia, over-distended bladder, or strangulated hernia, and if the patient, unaware of, or incapable of being made to understand, the necessity for immediate action, be unwilling to assent to the proposal, the Surgeon will truly be placed in a dilemma of anxious responsibility; between allowing the patient to fall a sacrifice to his obstinacy, ignorance, or timidity, and attempting, perhaps unsuccessfully, to rescue him from death without his consent. I believe the proper course for the Surgeon to pursue under such circumstances, is to judge for the patient in a matter on which he is clearly unable to form an opinion, and to compel him, so far as is legal and practicable, to submit to the necessary steps for the preservation of his life, or to put him under an anæsthetic, and, when he is unconscious, to perform any operation that may be required. In the event of the patient being insensible, as after an injury of the head, the Surgeon must necessarily take upon himself to act as the case requires. Children cannot be considered capable of giving an opinion as to the propriety of an operation; the consent of the parents alone is necessary; and, in their absence, if the case is an urgent one, the Surgeon must stand *in loco parentis*, and take all responsibility upon himself.

In order to persuade a patient to submit to a necessary operation it is often advisable to speak to him more encouragingly than the circumstances may justify, but if this be done the wife or husband or next friend must be made acquainted with the exact state of the case. In the after-treatment the same rule must be followed. It would often rob a patient of his last chance of recovery to tell him that his life was in imminent danger, but the fact must never be concealed from his friends, and the responsibility of communicating it to him, if they think fit to do so, may be left with them.

These points having been determined, the patient should, if possible, be *Prepared for the Operation*. In a great number of cases requiring operation, as in strangulated hernia, bad compound fracture, &c., no time is allowed for preparation, but the Surgeon must at once submit the patient to the knife, whatever the state of his health may be. But in the more chronic cases, time is given for improving the constitution. This preparation must not consist of any routine system of purging and starving, which is ill calculated to make the constitution fit to meet the call that will be made upon its powers; nor, on the other hand, in blindly adopting a tonic or stimulating regimen; but in adapting our means to the condition of the patient and the nature of the operation to be performed. The tendency to erysipelas, pyæmia, and diffuse inflammations generally, is materially lessened by supporting the

ferments in decomposition; thirdly, from the presence of dried particles of the discharges from wounds or sores; and, lastly, by the contagia of specific infective processes, whether general or local.

The gaseous products of decomposition, consisting of sulphuretted hydrogen, sulphide of ammonium, free ammonia, carburetted hydrogen, carbonic acid, and many others undoubtedly tend to aggravate the symptoms produced by the accumulation of the products of respiration; but it is impossible to separate the effects produced by the former from those of the latter, with which they must almost necessarily be complicated in a hospital ward. Parkes states that the putrefying animal matter which frequently accumulates about camps during war forms one of the principal causes of diarrhœa and dysentery; but it is only in military practice in which large numbers of wounded must occasionally be packed closely together and their wounds neglected for want of sufficient surgical assistance, that putrid discharges could accumulate to such an extent as to develop these diseases.

Secondly, the air of a ward containing many foul wounds has been shown to contain a great excess of organic matter, but it is impossible to separate the effects produced by it from those of foul air generally.

Thirdly, microscopic examination has demonstrated the presence of dried pus cells in the air of surgical wards in addition to the epithelium always met with in inhabited rooms. It has been supposed by some that these might possibly act as the material of contagion; that they may be the bearers of contagion cannot reasonably be doubted.

Lastly, the air of surgical wards is apt to be contaminated by the contagia of specific infective processes, such as hospital gangrene, erysipelas, pyæmia, &c. The exact nature of the contagium in all these diseases is not yet definitely ascertained. This much is certain, that the poison in all is particulate; it is never gaseous. Its activity can be destroyed by those chemical substances that we class as antiseptics. In the majority of cases the specific infective process commences in a wound, the discharges of which are in a putrid state; and those methods of treatment which are best calculated to prevent putrefaction also serve best to prevent the occurrence of infective processes, either local or general. It may now be said to be practically proved that all these unhealthy spreading inflammations are accompanied by the presence of microscopic organisms in the discharges, and often in the lymph spaces near the wound: and the view is now universally accepted that these micro-organisms are directly or indirectly the cause of the unhealthy processes, and that infection is brought about by the actual transference of some of these living particles from one patient to another. In the human subject erysipelas has been definitively proved to be caused by the invasion of the lymph-spaces of the skin by a specific fungus. Koch has shown that diseases closely resembling gangrenous erysipelas, septic infection, and pyæmia, as they occur in the human subject, can be artificially produced in animals; that each disease is accompanied by the presence of a distinct form of micro-organism, and that it can be transmitted from one animal to another by means of infinitesimal quantities of the blood or exudation fluids containing the characteristic organism. That the organisms or their spores retain their vitality after being dried has been clearly proved with regard to the somewhat analogous disease of anthrax in cattle. This disease is due to a rod-shaped organism, the bacillus anthracis, of such size that its life-

history can be accurately studied. It has been found that under certain conditions minute spores are developed in the bacillus, and that when this has taken place blood containing the virus may be dried and kept in that state for years without losing its virulence. In this state it is easily conceivable that it could be disseminated by the air. It is well known that the virus of vaccinia, small-pox, and scarlet fever equally resist the effects of drying.

Another fact of equal importance, which was first discovered by Pasteur and Toussaint, is that the virus of splenic fever and that of a peculiar form of septicæmia, common in fowls, known as chicken cholera, lose considerably in virulence if the organisms which form their essential part are cultivated under conditions which are not favourable to their growth. The converse, although equally well proved, is probably true also,—that a virus of low intensity increases in virulence if cultivated in a medium suited to its growth and development. Such a medium for the growth of pathogenic organisms is found in the feeble tissues and unhealthy sores of patients weakened by breathing the impure atmosphere of an over-crowded ward, and it is thus that infective processes of intense virulence may be developed. Our knowledge of the conditions under which the virus is developed in hospital gangrene and pyæmia, is still very far from perfect; but this much is certain, that they are essentially filth-diseases, and may, if the term be allowable, be manufactured in any hospital or house, however clean or well situated, by the accumulation within it of too large a number of patients suffering from wounds the discharges of which are in a state of decomposition. It is probable that the contagia of some of these diseases are destroyed by oxidation, especially if at the same time they are exposed to bright sunlight; but, be this as it may, it is evident that a want of free ventilation must lead to a concentration of such poisons as are disseminated by the air, and at the same time the patient's body will be rendered more susceptible to their influence as its vitality becomes lowered.

In the prevention of the effects of over-crowding we have to consider first the vitiation of the air by the natural processes of respiration and excretion; and, secondly, fouling of the atmosphere by the emanations from wounds and sores. The first of these causes of impurity is unavoidable, and it is only by providing sufficient air for each patient and changing it with sufficient frequency that its evil effects can be prevented. In determining the condition of the air of a room or ward the carbonic acid present is taken as the index of the degree of impurity, as it is easily estimated, while the determination of the organic matter is almost impossible. Parkes and De Chaumont give ·6 per 1000 volumes of total carbonic acid in the air as the limit of impurity allowable. Of this about ·2 is derived from respiration and the remainder is the normal quantity present in the atmosphere. In order to maintain the air at this standard an ordinary man requires to be supplied with 3000 cubic feet per hour. This is the minimum quantity of air that will suffice for the purpose, and it would evidently be unwise to trust to this. The rule, therefore, laid down is that at least 4000 cubic feet per hour must be provided. In order that this amount of air may be obtained without exposing the patient to draughts, a sufficient cubic space must be allowed for each patient, so that if the air be changed from three to four times per hour the requisite amount may be supplied. Under exceptional circumstances 1000 cubic feet per head might thus, with good ventilation, be made sufficient; but

gave rise to much discussion; viz., Do they influence the rate of mortality after operations? Simpson published statistics to show that the death rate was lessened by their introduction, while J. Arnott adduced figures to prove that it was materially increased; in amputation by 12 and in lithotomy by as much as 28 per cent. I am inclined to think that the rate of mortality was at first increased, and that this was due to two causes. First, that the Surgeon in his anxiety to give his patient a chance of life, not unfrequently operated by the aid of anæsthetics for diseases or injuries which would formerly have been left without an attempt at relief, and, secondly, that the introduction of anæsthetics led at once to an enormous increase in the number of operations performed. Hence hospital wards became more crowded than formerly with severe operation cases, and in the absence of any efficient antiseptic treatment, the causes of septic diseases became much more rife, erysipelas, septicæmia, pyæmia, and hospital gangrene more frequent, and the mortality proportionately increased. At the present time, however, owing to the improved treatment of wounds and better sanitary arrangements the mortality after operations is certainly lower than it ever was before the days of anæsthetics. Although, therefore, the statistics of modern surgery show no evidence of an increase of mortality due to the employment of anæsthetics, I cannot but think that chloroform and ether do exercise a noxious influence and lessen the prospect of recovery in certain cases. In some, especially if the kidneys are diseased, the prolonged vomiting that often follows their administration may depress the patient to such an extent that he may fail to rally after the operation. In other cases the irritating vapour either of ether or chloroform may aggravate existing bronchitis to a fatal degree. Some, therefore, purchase the immunity from suffering by a lessened chance of recovery, but there is no reason to believe that this is the case with a patient who at the time of the operation is in good health save for the local disease for the relief of which the operation is undertaken.

Administration of Anæsthetics.—Anæsthetics should never be given by a person unaccustomed to their use, and on whose capability the Surgeon has not full reliance; as nothing is more embarrassing during an operation than to have any doubt about the anæsthetic being properly administered. It must not, however, be imagined that they can be safely given only by a specialist. Every student before leaving the hospital may easily make himself sufficiently acquainted with the details of their administration to enable him to give them with perfect safety, provided he pays undivided attention to what he is doing and does not allow his mind to be diverted by watching the operation or by attempting to act both as anæsthetist and assistant.

No anæsthetic should ever be administered, except in cases of great emergency, to a patient who has eaten anything within three or four hours, lest it induce vomiting of the partially digested meal. On the other hand, the patient should not be exhausted by want of food, as may happen if the operation be performed early in the morning. Thus, if 9.30 be the hour fixed, he may have a cup of strong beef-tea at 6.30. Before any anæsthetic is administered, the patient should be asked if he wears false teeth, and if so, they should be removed. Any article of clothing about the neck, chest, or waist, that might cause interference with respiration or circulation must be loosened, and the patient should then be placed, if possible, in the recumbent position.

It is not necessary in all operations to administer the anæsthetic to the same extent. In the greater operations, such as amputation, lithotomy, or the ligature of an artery, enough should be given to completely paralyse muscular movement, as well as to suspend consciousness. In operations for hernia, also, and all other proceedings implicating the abdominal walls, if complete muscular relaxation be not induced, great inconvenience and no little danger may result. So, also, in very painful operations about the anus and genital organs, a full dose should be given. But for minor operations of short duration, it will be sufficient to give enough merely to suspend sensibility without inducing complete muscular relaxation.

Administration of Ether.—The best washed sulphuric ether should be used for anæsthetic purposes. Its specific gravity should be about ·720, and it should be free from alcohol, water, and fusel oil; the first two impurities may be recognised by the higher specific gravity of the mixture, and the last by a greasy stain left on paper, on which the ether is allowed to evaporate. Pure ether does not redden litmus paper. It should be kept in a well-stoppered bottle in the dark to prevent decomposition.

The administration may be effected by the application over the mouth and nostrils of a hollow sponge, or a towel folded into the form of a hollow cone, saturated with the ether; but it is better to employ some form of inhaler, as from its extreme volatility, unless some means are taken to economise it, the quantity required becomes a serious inconvenience. When given by means of a sponge, the face may be greased to prevent the pungent effects of the ether on the skin.

Amongst the numerous inhalers which have been invented of late years, Clover's smaller apparatus is perhaps the best (Fig. 1). It consists of a face-piece to cover the mouth and nose, to which a circular metal vessel to contain the ether is attached by a short metal tube. On the other side of this is a thin india-rubber bag, also connected with the ether-chamber by a short tube. The ether-vessel can be rotated on the face-piece, and according to the position in which it is placed, the course of the air passing through the apparatus varies. When it is turned so that the small indicator points to "no ether," the expired air passes into the bag without entering the ether-chamber, and is breathed again at the next inspiration. When at "full ether," the air in inspiration from the bag and expiration into the bag must all pass through the ether-chamber, which is warmed partly by the patient's breath, and partly by the administrator's hand on the outside. By a simple mechanical arrangement these variations in the direction of the air are effected without valves, and the instrument is for this reason less likely to get out of order. It is used in the following manner: Two ounces of ether are first poured into the ether-chamber, and the face-piece is fitted to the patient's face

Fig. 1.—Clover's Ether Inhaler.

with the ether-chamber, but without the bag, and with the indicator pointing to "no ether." The patient is allowed to breathe through it a few times to get accustomed to it. Then the bag is applied, and he commences to breathe the same air over and over again. This soon produces a slight stupefying effect, and after a few respirations the ether-vessel is rotated so as gradually to allow more and more ether-vapour to be mixed with the air. After a few more respirations the full amount of ether should be turned on. In this apparatus there is purposely no provision for the admission of fresh air, and if it were held firmly to the face for a sufficient time death from asphyxia must ensue. The administrator judges by the appearance of the face when air is needed, and removes the whole apparatus for one or more respirations as he may think necessary. Clover recommended that it should be removed at every sixth inspiration. The administration of ether by this apparatus gives rise to less choking than when the vapour is given from a hollow sponge.

The first effect of the administration of ether is to cause some irritation of the air passages indicated by coughing and a sense of suffocation, often very distressing to the patient, especially if the vapour be at first administered in too concentrated a form. This is very much diminished or completely avoided by using Clover's apparatus in the manner above described. After a few inspirations the sense of irritation subsides, and the vapour may then be given in full strength. The face soon becomes flushed, the breathing more deep and rapid, and the pulse is increased in frequency and fulness. At this time the patient feels a sense of warmth and tingling throughout the body. This stage is quickly followed by one of excitement, in which the patient may struggle, often violently, with the administrator and his assistants. His movements are more or less purposive, like those of a drunken man. This stage of excitement is most marked when the vapour is considerably diluted with air, as when it is given by means of a cone. The use of a good inhaler tends to shorten it, or to abolish it altogether. The patient frequently remembers what has happened during the stage of excitement, and the surgeon and his assistants should avoid any unguarded expression which might leave on the patient's mind an idea that he was roughly used. The face now becomes dusky, the skin is covered with perspiration, the respirations are hurried and deep, the pulse strong and full, and the pupil contracted. At this time a bright red rash not uncommonly appears on the chest and neck. The stage of excitement is usually followed by one of general muscular rigidity, the limbs are forcibly extended, the respiration may be temporarily suspended, and the duskiness of the face increased. The inhaler should now be removed for a few seconds till another breath has been taken. If the inspiration is delayed, the chest may be squeezed and the chin forcibly pulled up, which will usually have the desired effect. The stage of rigidity is quickly followed by complete muscular relaxation, the respiration becomes slower and shallower, the pulse falls slightly in frequency and force, the face becomes less dusky, the pupil dilates and the conjunctival reflex is abolished. The patient is now ready for the operation. A smaller quantity of ether is required to maintain the desired condition, and if Clover's apparatus is being used, it may be turned to "one-third" or "one-half ether." From the earliest stage of adminstration, the flow of saliva and mucus from the mouth and air passages is increased, often to such an extent as to cause considerable embarrassment in breathing, the respiration, both abdominal and thoracic, being violent and laboured. Under

these circumstances, the pharynx must be cleaned out occasionally with a sponge on a holder, and the head may be turned to one side to allow the secretion to flow from the mouth. However inconvenient these violent respiratory movements may be to the surgeon, he must not be tempted to change the anæsthetic to chloroform, as in the semi-asphyxiated state of the patient, there is great danger in so doing.

Experiments on animals have shown that the blood-pressure is at first increased during the administration of ether, and only falls when the animal is very deeply under its influence. The temperature is slightly reduced by prolonged administration.

The time required for the induction of anæsthesia varies, averaging abou five minutes if the ether is administered without an inhaler, but much less if Clover's apparatus be used. Habitual drunkards often require a large amount of ether to produce anæsthesia.

Secondary Effects of Ether.—Headache and prolonged drowsiness may follow the administration of ether, especially in the aged. In young and nervous women, hysterical excitement may appear and continue for some hours, or even days, but this need not excite uneasiness.

The *lungs* probably always become slightly congested during the administration of ether, but as recovery takes place, the pulmonary vessels unload themselves, and no inconvenience usually results. This is facilitated by admitting an abundant supply of fresh air to the room, and desiring the patient to breath several times fully and deeply after consciousness returns. In some cases the lungs do not unload themselves of the accumulated blood and of the excess of bronchial secretion that accompanies the congestion, and a process of slow asphyxia may set in, and prove fatal in a period varying from twenty-four hours to four or six days. This occurs in old patients suffering from chronic bronchitis and emphysema, and is not an uncommon cause of death after operations for strangulated hernia, as the strangulation is frequently caused by violent straining in coughing. It is also especially apt to happen in those cases in which it becomes necessary to bandage the chest, or in which deep respiration is attended with pain, as after amputation of the breast. Great care must, therefore, be taken not to constrict the chest-walls too tightly after such operations.

Continual nausea and vomiting are sometimes very distressing after-effects of ether, and may be productive of serious and even fatal results. Vomiting is less likely to occur if the patient can be left undisturbed and allowed to sleep off the effects of the anæsthetic. In many instances it is caused by the patient taking the ether too soon after a meal, and is then purely gastric, and usually occurs early in the administration. In other cases, it appears to depend upon cerebral disturbance of some kind, and in others, again, it is connected with kidney disease. But in any case, and from whatever cause arising, it is a serious symptom, and, if it continue, may turn the scale against the patient by the exhaustion to which it gives rise. It is best treated by ice or weak iced brandy and soda-water. Strong iced black coffee with bromide of potassium is occasionally useful, and in extreme cases a mustard plaster or even a blister to the epigastrium may be tried. Dudley Buxton recommends sipping hot water from a feeder or cup. About a teaspoonful should be taken at a time, and the temperature must be as high as the patient can bear. Tepid water increases the vomiting. For prolonged nausea, he advises

the administration of one minim of tincture of nux vomica in a teaspoonful of hot water every ten minutes for one hour.

In *certain diseased conditions*, such as, early phthisis, chronic bronchitis, and various forms of heart disease, the administration of ether requires much care. In persons who are epileptic, and in red-faced apoplectic-looking men, it must be cautiously administered, as in the early stages it is apt to cause much cerebral excitement. Ether is usually considered to be especially dangerous in advanced kidney disease. These conditions will be more fully discussed when considering the choice of an anæsthetic (p. 35).

Death from the Administration of Ether may arise from various causes. Cautley Dawson, in the British Medical Journal, March 2, 1878, published a collection of eighteen cases in which death took place either during or soon after the administration of ether. Of these he excluded nine, on the grounds that ether was not the only anæsthetic used, or that it was possible the death might have been due to other causes. Of the remaining nine cases, in seven the heart continued to beat for some time after respiration had ceased, and in two this point was doubtful. All the patients died from asphyxia, as indicated by the dusky face, the shallow respiration, and the long interval, varying from four minutes to fifteen or more, between the first manifestation of serious symptoms and death. At the post-mortem examination the lungs were found gorged with blood in five of the seven cases examined; in one more "the pulmonary artery was said to be engorged"; in one only were the lungs pale, and in this case the symptoms did not come on till one hour and a half after the patient had left the operating theatre. These cases confirm the generally received opinion, founded on experiments on animals, that ether kills by acting primarily on the respiratory centre, and that the heart is never affected first. Ether is said, therefore, to possess the advantage that, when it does give rise to dangerous effects, the serious symptoms develop gradually, and give plenty of time for the adoption of the necessary measures to restore the patient. Amongst the fatal cases recorded, there are, however, undoubtedly some in which there seems good reason to believe that the respiration and the heart's action ceased simultaneously; but even in these, duskiness of the face is most commonly mentioned as the first symptom, and very probably there was some degree of asphyxia before the heart ceased acting. It is quite easy to understand how a weak or dilated heart may fail under the influence of ether, in consequence of obstruction to the pulmonary circulation from the direct irritation of the lungs by the ether vapour, and from the semi-asphyxia caused by excessive accumulation of mucus in the bronchial tubes.

Many patients who were previously suffering from bronchitis and emphysema have also undoubtedly been killed by slow asphyxia consequent upon the aggravation of the disease by the irritation of the ether vapour. In a few recorded cases, death has taken place within a few hours from acute œdema of the lung.

Owing to the extremely violent respiration often met with during the inhalation of ether, blood or vomited matter is readily drawn into the air passages. In a fatal case which occurred at University College Hospital after an operation for strangulated hernia, the patient recovered consciousness and survived two hours. At the post-mortem examination, fæcal matter was found in the bronchi, even in their smaller divisions.

Administration of Ether by the Rectum, which was suggested and practised by Pirogoff so long ago as 1847, has lately been advocated by Mollière, Wanscher, and others, as a means of giving that anæsthetic when it is impossible to administer it by inhalation, as in operations on the jaw or tongue. The bowel should be cleaned out by a purge and an enema before the operation. The ether is placed in a bottle, connected by means of an india-rubber tube with a cannula, which is inserted into the rectum. The bottle is then gently heated in warm water. Care must be taken that no ether enters the bowel in the liquid form, as it would cause intolerable irritation. The general effects are the same as in administration by inhalation, and the dangers are also identical, with one exception. This method of administration is said not to cause the profuse secretion of mucus which is often so embarrassing during inhalation of ether. On the other hand, during administration it may give rise to considerable distension of the abdomen, and it is not uncommonly followed by diarrhœa. In a case of fibrous polypus of the nose in which ether was administered in this way for Marcus Beck by Dudley Buxton, the boy was kept most comfortably under the anæsthetic for one hour and a half. During the following night he passed two small loose motions containing much blood and mucus and innumerable columnar epithelium cells. No further unpleasant symptoms followed. The diarrhœa has, however, been known to be fatal in at least one case. Recovery is sometimes slow, and may be hastened by passing a long tube up the bowel as soon as the operation is finished. It is a question still to be determined whether this method is of any practical value. It might be serviceable in some cases of chest and lung surgery, in which there is reason to avoid the risk of a cardiac depressant such as chloroform, and in which great danger may be anticipated from the excessive secretion of mucus accompanying the inhalation of ether.

Administration of Chloroform.—Chloroform should be kept in a well-stoppered bottle protected from light, otherwise it may undergo decomposition with the formation of free chlorine and hydrochloric acid, both of which are apt to irritate the lungs. Pure chloroform is neutral in reaction; its specific gravity is 1·497. Distilled water shaken up with it, and allowed to separate by standing should not give a precipitate with nitrate of silver.

Chloroform may be administered either on lint or on a handkerchief or through an inhaler of some kind. The following is the way in which it may most safely be given without any special apparatus. The face should first be greased with cold cream or oil to prevent any accidental blistering of the skin. About a drachm of chloroform is then poured upon a piece of lint about four inches square, and four layers thick; this is held at a distance of about three inches from the nose of the patient, so as to permit a very free admixture of air with the first few inhalations of the vapour. After the lapse of about half a minute, the lint is brought nearer to the patient's nose, to within a distance of perhaps an inch, never being allowed to touch. At the same time a porous towel, not doubled, is lightly laid over the face of the patient and the hand of the operator, so as to limit the escape of the chloroform-vapour, but not to prevent the admission of air. During the whole time, it is the duty of the administrator to keep his hand on the temporal pulse, to watch the breathing, and occasionally to examine the pupils of the patient.

The method just described has been shown by experience to be one of the

most practically useful modes of administration, and to be quite as safe as any other. A committee of the Medical and Chirurgical Society of London, which reported on the administration of chloroform in 1864, determined that $4\frac{1}{2}$ per cent. is the maximum amount of the vapour which can safely be mixed with the air the patient inhales. Sir Joseph Lister has shown by experiment that the proportion given off from a folded piece of lint, used as above described, is far below this, and there is therefore no necessity for the use of the complicated inhalers which have sometimes been recommended. Whatever leads the administrator to rely upon anything but careful and continuous observation of the symptoms of the patient is an evil, and all inhalers have a tendency to do this. The only merit that can be claimed for any form of inhaler is that the mixture of chloroform and air given is of constant strength, whereas, when administered on lint, the vapour given off is most powerful immediately after the lint has been wetted with the anæsthetic, and gradually diminishes in strength as the administration continues. This may be obviated by the following plan, which is now recommended by Lister in the place of that which he formerly advocated. Put one corner of a stiffish towel

Fig. 2.—Junker's Chloroform Inhaler.

over the face in such a way that the point is over the chin; opposite the forehead gather up the towel in three or four puckers, and, if necessary, pass a pin through them; there is thus produced a concave mask, which covers the mouth and nose tolerably accurately. By allowing a drop or two of chloroform to fall upon it from a drop-bottle every few seconds, the central part is kept constantly wet over an area of about two inches in diameter. By this means a vapour of practically constant strength can be easily administered.

A useful form of inhaler in many cases is that known as Junker's (Fig. 2). In it air is blown by a bellows through a bottle to a vulcanite or flannel face-piece. The strength of the vapour inhaled depends upon the amount of air which is forced through the chloroform. Its use presents, however, no important advantage over the simpler methods of administration above described, except in operations upon the face, mouth and throat. In these the face-piece may be replaced by an elastic tube which can be passed through the nostril, so that the anæsthetic may be continuously given during the

operation. It has one special danger; if the bottle be filled too full or be accidentally tilted, pure chloroform may be blown into the mouth, or even into the lungs—an accident which has been known to be fatal. This accident may be avoided by not putting more than six or eight drachms of chloroform into the bottle, and by guarding the tube through which the vapour passes by a second one over it.

However administered, chloroform should not be given too suddenly nor in too concentrated a form. If lint be used, it must not be too much saturated nor be held too closely applied to the mouth and nostrils, or the patient may not be able to get sufficient air, and may speedily become partially asphyxiated, choking violently, struggling to get free, and becoming purple in the face. Care should be taken not to compress the abdomen in holding the patient; for, as the respiration becomes chiefly diaphragmatic, it may be seriously interrupted by any pressure on the abdominal wall. As chloroform has a sedative action on the heart, the patient should not be raised up suddenly if this can be avoided, while he is deeply under its influence, lest dangerous syncope should ensue. Hence, also, it is dangerous to administer it in those operations that require to be performed whilst the patient is erect. With due caution, it may be given with safety to individuals of all ages. I have operated on infants less than a week old, as well as on octogenarians, under its influence. In administering it to young children, Snow recommended its dilution with rectified spirit, but this is unnecessary.

The effects of chloroform resemble generally those of ether. Chloroform, however, usually gives rise to less excitement than ether, and being less irritating to the lungs, causes less choking and sense of suffocation, and scarcely any increased secretion from the pharynx and bronchial tubes. It slightly stimulates the action of the heart during the early stages of its administration, but this is quickly followed by depression with lowering of blood pressure. Muscular rigidity during the early stages is rarely as marked as with ether.

The effects of the administration of chloroform vary considerably in different patients. Occasionally the patient becomes unconscious as quietly as in the natural process of going to sleep. More commonly the first effect produced is a feeling of warmth at the pit of the stomach. This is followed by some choking sensation and violent beating of the heart, with noises in the head. At this period the patient begins to lose self-control. He talks excitedly, but not absolutely incoherently, and the struggling which frequently takes place assumes the form of efforts to remove the chloroform from his face, or to escape from the hands of the Surgeon and his assistants. At this time the pulse is quicker and more forcible than natural, the respiration is hurried and deep, the pupil acts readily to light, the face becomes flushed, and if the struggling is violent, it may be purple and turgid. This period of excitement is quickly followed by loss of consciousness. The struggling may still continue, but the movements are purposeless, and such words as he utters are disconnected and incoherent. At this stage, a violent tonic contraction of every muscle in the body may take place; respiration is arrested, and the face becomes dusky. It is wiser not to force the chloroform when this condition is present. If the lint be removed from the face for a few seconds the spasm ceases, and a few good deep respirations remove the lividity of the face, when the administration may be recommenced without danger. More commonly the stage of excitement is followed directly by that of complete insensibility,

a few deep, hurried respirations separating the two. The face now becomes pale, but not livid, the respiration is regular, slow, and shallow, the pulse falls in frequency and force, all the voluntary muscles become flaccid, and reflex movements can no longer be induced by pinching the skin or touching the conjunctiva. The pupil is at first contracted, but afterwards becomes widely dilated and insensible to light; and this is a sign that the administration has been pushed to the furthest limits consistent with safety, and must be suspended till the pupil again responds to light. Immediately before this stage is reached the patient may snore loudly; but in deep anæsthesia, the respiration, being slow, shallow, and chiefly diaphragmatic, is usually not sufficiently violent to produce any sound. What may be called the healthy snoring of deep anæsthesia must be distinguished from the loud inspiratory stertor indicative of closure of the glottis. The latter is a sign of danger, and necessitates the immediate removal of the chloroform until the stertor has passed off and has been followed by three or four healthy respirations. When fully anæsthetised, the patient is at the verge of death, and requires the most careful watching by the person who administers the chloroform; his fingers should be kept constantly on the temporal artery, as the most convenient point for feeling the pulse, and his eyes should not be taken away from the countenance of the patient. He must watch, on the one hand, for lividity indicative of impending asphyxia, and on the other, for pallor showing feebleness of the heart's action. The breathing must be carefully observed, and the administrator must not be content with seeing that the movements of respiration continue, but must feel with his hand that air is actually passing in and out, as in closure of the glottis the respiratory movements continue regularly for some time after air has ceased to enter. Many accidents doubtless arise from the patient being thus allowed to become partially asphyxiated, and the heart's action greatly enfeebled; and when, as usually happens, the obstruction passes off and is followed by a deep inspiration, instead of pure air, which is so greatly needed, a concentrated dose of chloroform vapour is supplied, which suddenly checks the action of the weakened heart.

The **Secondary Effects of Chloroform** differ but little from those of ether (p. 23). Vomiting occurs with about the same frequency and severity, and requires the same treatment. Chloroform seems to be less irritating to the lungs, and consequently gives rise to less secretion and congestion. In old bronchitic patients it may, however, like ether, aggravate the condition, and in this way indirectly prove fatal. Excitement on recovery is less common than with ether.

Death from Chloroform may occur by *Coma*, *Asphyxia*, or *Syncope*.

Death by *Coma* is very rare, and chiefly occurs in epileptics, or in patients suffering from advanced kidney disease. In these cases the breathing becomes stertorous, the face is livid, and the pupil widely dilated. There may be a general convulsion, especially in epileptics. The pulse continues to beat with good force. In spite of the removal of the anæsthetic the stertorous breathing and lividity of the face continue, the respiration gradually becoming slower and more irregular till it ceases altogether, the heart continuing to act to the last. These cases are quite exceptional; the vast majority of deaths from chloroform occur from *asphyxia* or from *syncope*.

Death by *Asphyxia* may be produced in at least four ways. 1. It has been shown by experiments on animals that chloroform will with certainty cause

death by paralysing the respiratory centre if administered in a sufficient dose, and for a sufficient time, and the same is doubtless true in man. According to the committee of the Royal Medical and Chirurgical Society (1864), if the proportion of chloroform vapour to air does not exceed $4\frac{1}{2}$ per cent. respiration will always be arrested before the action of the heart ceases. The recent Hyderabad Commission, after a prolonged and most ably conducted investigation, reported, however, that chloroform given in any dose and in any way invariably arrests respiration first. In fact, they doubt whether sudden death ever occurs from the direct action of the chloroform upon the heart or cardiac centres. Against this we must put the fact that previous observers had succeeded, or thought they had succeeded, in causing primary arrest of the heart's action, and that large numbers of apparently authentic cases are on record in which the pulse has ceased before the breathing, or both have ceased simultaneously in the human subject. The question is not yet satisfactorily settled, but this much may be said to be certain, that an overdose of chloroform kills as a rule by arresting respiration first, and only exceptionally by primarily acting on the heart. 2. It is perhaps possible that through careless administration, especially with an inhaler, sufficient air may not be admitted to maintain the respiratory function. 3. Sir Joseph Lister describes the production of asphyxia from spasmodic closure of the upper opening of the larynx, the folds of mucous membrane above the apices of the arytænoid cartilages being carried forwards till they are in contact with the base of the epiglottis, which remains erect and unchanged in position. This theory was founded on observations of the larynx during the production of that peculiar laryngeal stertor which usually precedes the stoppage of the respiration. On pulling the tongue forcibly forward, the arytænoid cartilages were seen to be drawn backward, and the opening of the larynx made free again; and this seemed to be due to reflex action and not to the mere mechanical act of drawing the tongue forwards. This is quite possible during anæsthesia, as the reflex functions of deglutition and respiration are not affected by chloroform as administered for a surgical operation. The closure of the glottis giving rise to this peculiar crowing stertor has been with more probability ascribed to paralysis of the abductors of the cords; but against this it may be argued that it frequently occurs before the patient is very deeply under the influence of the anæsthetic. However it may be caused, the obstruction to the respiration may pass unnoticed till the pulse stops, as the heaving of the chest may go on for some time after air has ceased to enter; the only signs of the state of the patient being the gradually increasing lividity of the face, and the fact that no air is entering or coming out, which can be ascertained by feeling with the hand over the mouth. Lister is of opinion that many of the deaths from chloroform, in which the heart has been said to stop first, were cases of this kind. He insists on the necessity of pulling the tongue forcibly forwards with forceps, and not merely drawing it out in front of the teeth, if the spasm is not immediately relieved by the simpler process recommended by Clover of pulling the chin strongly upwards. 4. Asphyxia may also be caused by the impaction of half-digested food in the larynx during vomiting, and false teeth have also been known to slip into the larynx during the administration of chloroform, and the same accident has happened with the gag used in dental operations.

In death from *Syncope* the patient becomes pale and faint; the pulse beats in a flickering manner and then ceases, though respiration may continue for

some seconds longer. This accident is more likely to occur in individuals who are depressed either by mental emotion or by physical debility, and it is not unfrequently connected with fatty heart. Death from syncope under chloroform may arise in four ways. 1. After very prolonged and severe operations, especially if associated with loss of blood, the heart's action may become gradually more and more feeble, and finally cease altogether. It is impossible in such cases to say how much is due to the chloroform and how much to the shock of the operation. 2. If the chloroform vapour be administered in too concentrated a form, it is probable that it may cause death by paralysing the cardiac centre. 3. In some rare cases death has occurred suddenly at the very commencement of the administration, before a sufficient quantity could have been absorbed to have any direct influence on the central nervous system. In these cases death is believed to be due to reflex inhibition of the heart through the vagus, the afferent impulse being developed by the irritating action of a very concentrated vapour of chloroform on the mucous membrane of the larynx, trachea and bronchi which is supplied by the sensory branches of the pneumogastric nerve. Death in these cases is due to shock. This is a very rare accident, and is probably dependent on some idiosyncrasy in the patient. 4. Death has been known to occur from reflex inhibition of the heart, owing to an insufficient dose of the anæsthetic having been given and the patient being still conscious of the pain. In these cases death might have been prevented by a more thorough administration of the anæsthetic.

If there is reason to fear syncope on account of the feeble state of the patient, a small quantity of brandy or ammonia may be given before commencing the inhalation. It has been suggested that death from reflex cardiac inhibition might be prevented by the subcutaneous injection of a dose of about $\frac{1}{20}$ grain or less of atropine, which is known to abolish temporarily the inhibitory function of the vagus. The accident is, however, so rare that few Surgeons would be found willing to give every patient a large dose of atropine before venturing to administer chloroform. It is best avoided by careful administration of the anæsthetic. The proportion of chloroform vapour to air should at first be very small and should be gradually increased. This is done by varying the distance of the lint or towel from the patient's face. Should there be coughing or repeated acts of swallowing with the first few inspirations, showing irritation of the mucous membrane of the larynx and trachea, the chloroform must at once be removed to some distance from the face and again gradually approximated.

During the whole administration the pulse and respiration should both be carefully watched. To direct attention to one only is a mistake, for, though in the vast majority of cases, the breathing will give the first indication of danger, yet we must not forget that chloroform is a cardiac depressant and in a prolonged operation may aid in inducing cardiac failure. It is the anæsthetist's duty to watch the state of the patient carefully and to warn the surgeon should he think it dangerous to continue an operation which can be abandoned or quickly brought to an end.

A few rare cases have been recorded in which, owing to an idiosyncrasy on the part of the patient, no amount of chloroform produced any anæsthetic effect.

Alcohol, Chloroform, and Ether, or, as it has been called, "the A. C. E. mixture," consisting of alcohol 1, chloroform 2, and ether 3 parts, is

sometimes useful in irritable or feeble patients. The ether is intended to prevent the depressing action of the chloroform upon the heart, the chloroform to diminish the irritation of the air passages by the ether, and the alcohol to dilute the anæsthetics. It must be administered on lint or on a folded towel, in order that the three vapours may be given off in the proper proportion. If the mixture were administered from an ether apparatus, in which the anæsthetic is put in a liquid form into a chamber in the instrument, the ether would be given off at first most abundantly, being by far the most volatile of the three, and the proportion of chloroform vapour would be gradually increased as the administration continued. For the same reason, if the mixture be not freshly prepared, the proportion of ether is apt to be diminished.

Chloroform and Morphia. In very long operations, anæsthesia may be maintained with a smaller amount of chloroform if a quarter of a grain of morphia be injected subcutaneously immediately before commencing the administration. In cerebral surgery this plan is recommended by Horsley, as the morphia temporarily constricts the vessels of the brain and thus diminishes hæmorrhage during the operation. It must be remembered that morphia, although it is safely administered with chloroform, increases the dangers of ether. Tripier of Lyons recommends the addition of a small quantity of atropine to the morphia injection.

Bichloride of Methylene was recommended as an anæsthetic by Richardson, and a substance which passed by this name was extensively used in Guy's Hospital and at Moorfields Ophthalmic Hospital. In 1883, however, Regnauld and Villejean published a paper, in which it was shown that the liquid sold under this name is nothing more than a mixture of four parts of chloroform with one part of methylic alcohol. The advantages claimed for this mixture over pure chloroform and ether were, greater rapidity of action, complete and rapid recovery, and the absence of muscular rigidity during administration, and of unpleasant after-symptoms. The rapidity of action was, however, obtained by giving the vapour in as concentrated a state as possible, all unnecessary admission of air being avoided. It is evidently not a safe proceeding to administer any preparation of chloroform in this way. If it be used at all, it must be given in the same way, and with the same precautions as pure chloroform.

Nitrous Oxide Gas was the first anæsthetic used, but its employment was soon discontinued, ether, and subsequently chloroform taking its place. It was re-introduced in 1863 as an anæsthetic by the American dentists. It is an admirable anæsthetic, rapid in its action, safe in its administration, and seldom giving rise to any unpleasant after-effects. The class of cases in which nitrous oxide is applicable is restricted, owing to the short duration of the anæsthesia produced by it, and the suddenness of the return to consciousness, making the after-smart of the operation almost as severely felt as the cut itself could have been. Nitrous oxide is chiefly of use in operations which involve no cutting, as in the forcible bending of stiffened joints, the avulsion of toe-nails, extraction of teeth, &c.; or in those cutting operations which are completed by a single stroke of the knife, as the opening of an abscess.

In order to produce the desired effect, without causing that violent excitement which gained it the name of "laughing gas," it must be administered pure, without admixture of air. In order to do this, a proper

apparatus, with a closely-fitting face-piece, to cover the mouth and nose, must be used. The gas is supplied for use compressed in iron bottles. The bottle is connected with the face-piece by a tube, in the middle of which is an india-rubber bag, differently placed in different instruments. The principle of all is, however, the same, viz., that after the face-piece has been firmly applied, the bag is distended with gas by turning the stop-cock connected with the iron bottle. The patient then breathes the gas from the bag. In some instruments, by an arrangement of valves, the expired gas passes into the air, fresh nitrous oxide being supplied for inspiration. In others the patient breathes backwards and forwards into the bag, inhaling the same gas several times. The former method is preferable, although necessarily causing an increased consumption of gas. In the latter method some gas is lost by escaping from under the face-piece, and its place is supplied by allowing a fresh stream to flow in from the iron bottle. Nitrous oxide is an irrespirable gas, and as no air is mixed with it, the effects produced are, to a great extent, those of asphyxia. It differs, however, from the asphyxia produced by obstruction of the air-passages in this, that the elimination of carbonic acid gas continues to a certain extent, so that although the blood ceases to receive oxygen it does not become overcharged with carbonic acid, and consequently a few breaths of fresh air remove all traces of the temporary asphyxia. The process of anæsthesia by nitrous oxide is not, however, asphyxia and nothing else; a certain proportion of the gas is absorbed, and exerts an influence resembling that of other anæsthetics on the nervous centres. Experiments on animals have shown that, like ether, it always stops respiration before arresting the action of the heart. In the administration of laughing gas the following symptoms are observed. After a time, varying from a few seconds to half a minute, according to the freedom with which the patient inhales the gas, a slight lividity of the face is noticed, and a choking sensation may be felt. In less than one minute, as a rule, this lividity becomes extremely marked, the vessels of the face are injected, there is often some twitching of the eyes and limbs, and the breathing is deeper than natural. At this stage sensation and reflex movements are abolished, and a momentary operation may be performed. Sometimes the patient is conscious that something has been done although he feels no pain, and his ideas are confused. If the operation be more than momentary, the administration of the gas must be continued a few seconds longer. The face then becomes livid, the eyes protrude, the pupils dilate, and the whole appearance of the patient is alarming to an inexperienced bystander. The pulse becomes unsteady, and the respiration slow and stertorous. This is the extreme point to which the administration can be carried, for, as before stated, the gas is irrespirable, and if administered for a sufficient length of time, must necessarily be fatal. Even when carried to this extreme point, however, a few breaths of fresh air suffice to restore the patient perfectly. Occasionally there is some excitement as recovery takes place, but this soon passes off. Vomiting is very rare. During the period of insensibility, and the excitement following it, the patient is very apt to dream; and consequently it is extremely unwise for a medical man to administer laughing gas, or in fact any anæsthetic, to a female patient except in the presence of a third person, as charges of criminal assault have been made under these circumstances, very possibly in perfect good faith on the part of the patient.

Death from the administration of laughing gas has occurred only with extreme rarity. In 1877 it proved fatal to a medical man, apparently from over-distension and paralysis of the right side of a fatty heart, consequent on the obstruction to the pulmonary circulation which always occurs from the partial state of asphyxia which the gas induces. In another case, a patient in the last stage of phthisis failed to rally and died less than one hour after the gas was administered. Several other fatal cases have occurred from the gag used by the dentist breaking or slipping and becoming impacted in the larynx. The only conclusions to be drawn from these cases are, that it is not advisable to give laughing gas in cases of extreme phthisis or fatty heart, and that it is wise for the administrator to have by his side the instruments necessary for the operation of laryngotomy or tracheotomy whenever the operation is one involving the use of a gag. In certain conditions it is said to have caused somewhat serious after-effects. Thus Lafont says he has seen it cause abortion at the fifth month, and the relapse of epilepsy in a boy who had been free from fits for many years. It has also been known to cause a great exacerbation of the disease in diabetes.

Nitrous Oxide and Ether.—As has already been stated, each of these agents possesses certain disadvantages—the anæsthesia produced by nitrous oxide not being sufficiently persistent to admit of the performance of prolonged operations, that of ether being slow of production and often attended by considerable excitement. By the successive administration of the two anæsthetics, these inconveniences are removed, and the advantages of both are secured. The plan adopted by Clover consists in the rapid induction of anæsthesia by the nitrous oxide, and the maintenance of this insensibility by the use of the vapour of ether. In this way one anæsthetic supplements the other, and the rapidity of the one is combined with the persistence of the other.

Ethidene, Amylene, Ethyl-bromide, Chlorethylidene, and various other substances possessing anæsthetic properties have been tried, but have not shown any definite advantages over the agents in common use.

Comparison between Ether and Chloroform.—The history of Anæsthetics furnishes an illustration of the mutability of professional opinion. Ether was the only anæsthetic employed for the first year after the discovery of its use as an anæsthetic. It then so completely gave way to chloroform in this country and generally throughout Europe, that a confusion arose in the public mind as to the real discoverer of Anæsthesia; and Sir James Simpson, who was the first to employ chloroform and to whose energy its general adoption was mainly due, was very commonly considered to be the discoverer of Anæsthetics. In some hospitals, however, and more especially in those of Boston, the birthplace of surgical Anæsthesia, the faith in ether has never been shaken, nor its use abandoned for that of any other agent. In London a change of opinion has taken place, and for the last few years ether has been used as the general anæsthetic, at least in hospital practice and in the hands of special anæsthetists. In Scotland chloroform still remains the agent chiefly in use.

The comparison between ether and chloroform has to be made from three points of view:—1. As to safety; 2. As to convenience; and 3. As to suitability in special cases.

1. *As to safety.*—No anæsthetic is absolutely safe, but with ordinary care and some degree of experience, both ether and chloroform may be administered

with very trifling danger, so trifling indeed, that many a surgeon goes through a long hospital experience without meeting with a fatal case. There are no data at present before the profession from which the relative danger of the two agents can be deduced with anything like certainty, but it is generally acknowledged by those who have much experience of both that ether is safer than chloroform. In University College Hospital ether has been used as the ordinary anæsthetic for many years, yet during that time the few deaths which have occurred during anæsthesia have all been from chloroform. In the hands of an unskilled or careless administrator there can be little doubt that chloroform is more dangerous than ether. It kills more suddenly, and gives less time for restorative measures to be taken. The extreme view taken by some advocates of chloroform, that that agent is absolutely safe if undivided attention be given to the respiration, and that every fatal case is more or less the fault of the administrator from not doing so, may be true of dogs and monkeys, but there is abundant clinical evidence that it is not true of man. There is equally insufficient evidence to justify the opinion of some of the supporters of ether that to give chloroform is so dangerous as to be scarcely justifiable. Both agents are sufficiently safe in the hands of a careful administrator to justify their use, but circumstances may make one or the other preferable. Where no special conditions are present to determine the choice, ether should be preferred as the safer.

2. *As to convenience.*—Chloroform is more convenient than ether in many ways, and, indeed, it was this that led to its general adoption. It can be more easily administered without any special apparatus ; it induces anæsthesia more rapidly, and the quantity required is much smaller. These advantages are most important in military and naval practice, where the large bulk of ether required would often render its employment difficult. So, also, in country practice, where Surgeons have often to work single-handed, or with imperfect assistance, chloroform is the more convenient anæsthetic. In hot climates, the extreme volatility of ether makes its use practically impossible. To the patient, chloroform is usually pleasanter, causing less coughing and sense of suffocation.

Under favourable circumstances, however, all these advantages of chloroform over ether disappear. With a proper inhaler anæsthesia is induced as quickly with ether as with chloroform, and can be kept up as easily. The quantity required is not so great as to be an inconvenience in most cases, and all unpleasantness may be avoided by giving laughing gas first. In fact gas and ether is by far the least unpleasant anæsthetic that a patient can take for a major operation. The after-effects of the chloroform and ether are so much alike that on this ground there is little to choose between them. Excitement on recovery is more common after ether. The penetrating and long persistent odour of ether is often very annoying to the patient on recovery, and in this respect it is more unpleasant than chloroform.

During the operation, putting the question of safety on one side, chloroform is undoubtedly more convenient to the Surgeon. Ether frequently causes great venous congestion, and in this way increases the oozing from the wound. It is said, also, to increase bleeding by causing vaso-motor paralysis. It is more difficult to get perfect muscular relaxation with ether, and clonic spasms are not uncommon, which, combined with the violent respiratory movements, are often most embarrassing to the Surgeon.

3. *As to suitability.*—In the majority of cases, chloroform and ether are equally suitable, and the Surgeon must be guided then by the convenience of one or the other, and by his belief as to their relative safety. In certain cases that will be mentioned below, one is preferable to the other.

Choice of an Anæsthetic.—Only the four anæsthetics in common use will be considered here: Laughing Gas, Ether, Chloroform, and the "A. C. E." mixture.

The *Duration of the Operation* influences to some extent the choice of the anæsthetic. For all proceedings not likely to last more than one minute gas should be used, if possible. When it is intended to keep the patient insensible for many hours, as in compression of the aorta for aneurism, chloroform is preferable, ether being inconvenient from the excessive bronchial secretion which it causes.

The *Age of the Patient* is also of importance. In infants and children under seven or eight chloroform is more convenient, and is very safe. Ether, if given without an apparatus, causes more struggling and choking, and if with an apparatus, frightens the child greatly. On the other hand, children take chloroform very well. Some administrators prefer the "A. C. E." mixture, and if the child is very young or weak it is perhaps safer.

In older children and healthy adults gas and ether is the pleasantest and safest anæsthetic for all major operations, and gas alone for minor operations of short duration, when these agents can be obtained. In military and country practice and in hot climates there is no doubt chloroform will continue to be the chief anæsthetic on account of its greater convenience; in cities and large towns ether will probably soon become the chief anæsthetic on account of its greater safety. Its use is increasing both in this country and on the continent.

In aged people ether is dangerous if they suffer at all from bronchitis and emphysema, and chloroform, which scarcely increases the bronchial secretion, is to be preferred. If the patient is very feeble, the "A. C. E." mixture may be used as being less irritating and depressing. If the lungs are perfectly healthy, ether may be used even in advanced age.

The *Nature of the Operation* has an important influence on the choice of the anæsthetic. In operations about the face, mouth, and throat, chloroform is to be preferred, as it is more easily administered by a tube through the nose and a Junker's apparatus (Fig. 2). In brain surgery chloroform and morphia (p. 31) is always to be used, as the venous congestion that ether gives rise to would be a most serious inconvenience, and the morphia moreover diminishes bleeding by causing some degree of cerebral anæmia. Chloroform is, for the same reason, to be preferred in operations about the root of the neck, such as ligature of the subclavian. In any operations about the head or neck in which a cautery is likely to be used, ether must be avoided, as its vapour is explosive. In operations upon the abdominal viscera most Surgeons prefer chloroform, as ether may fail to cause perfect relaxation, and the violent respiratory movements it often gives rise to might greatly embarrass the operator.

In any *Disease of the Lungs* nitrous oxide should be avoided on account of the partial asphyxia induced during its administration, and chloroform or the "A. C. E." mixture is preferable to pure ether, being less irritating. The accumulation of mucus caused by ether is especially dangerous in the

bronchitis and emphysema of old people, in some cases leading to slow asphyxia a few hours or days after the operation. In these cases no anæsthetic is free from danger, but chloroform is probably the safest.

In *Disease of the Heart*, accompanied by feeble action due to fatty degeneration or dilatation, ether may be used; chloroform, being a cardiac depressant, is dangerous. Ether must, however, be given with caution, as the venous obstruction it sometimes gives rise to may be too much for the feeble heart to overcome. For the same reason, gas is dangerous in such cases. Slight valvular disease of the heart has little influence on the choice of the anæsthetic. If there is reason to believe that there is advanced *arterial degeneration* ether must be given with caution, lest rupture of a vessel in the brain should occur during the stage of excitement; but as the heart in these cases is frequently diseased, chloroform also causes anxiety. It is best, perhaps, under these circumstances, cautiously to give the "A. C. E." mixture.

In *Disease of the Kidneys*, with much albumen in the urine, all anæsthetics are dangerous, especially ether. In *Diabetes* nitrous oxide is said to have caused a fatal exacerbation of the disease. Probably chloroform is the safest anæsthetic in this condition. In *Epileptics* no anæsthetic is free from risk, but from the experience derived from brain surgery, probably morphia and chloroform would be the safest. In *Hysterical and Insane* patients chloroform, preceded or not by a hypodermic injection of morphia, is probably the best as giving rise to the least excitement. In patients who are under the *influence of opium* it is wiser to give chloroform, as ether under these circumstances might dangerously depress the respiratory centre or choke the lungs with mucus, leading to slow asphyxia before the patient recovered sufficiently from the opium to cough it up.

If, during anæsthesia from ether, it is thought necessary to change to chloroform in order to obtain more perfect relaxation, or on account of very excessive accumulation of mucus in the pharynx and lungs, this must not be done suddenly, lest the already embarrassed heart be brought to a standstill. The patient must be allowed partially to recover and to clear his lungs before the new anæsthetic is given.

The **Administration of an Anæsthetic during Shock** was at one time objected to on the ground that it would still further depress the patient, and that the pain of the operation would be a good stimulus to rouse him. Common sense, as well as experience, are against such an argument. Pain is far more depressing than any anæsthetic. Unfortunately we cannot entirely prevent the additional shock caused by an operation under these circumstances even by anæsthetics, for it is an interesting physiological fact that shock is produced on the system even though the patient be completely anæsthetised. This is particularly noticeable in castration, in which, at the moment when the cord is cut, the pulse falls several beats or stops momentarily, even though the patient be quite insensible. Hence, it may be argued that, although anæsthesia saves the patient that amount of shock which arises from pain, it does not relieve him entirely from the impression produced on the system by a severe mutilation.

As an anæsthetic to be administered during shock ether undoubtedly is preferable to chloroform. Owing to its stimulating action on the heart the pulse will frequently improve during the operation, and it can be pushed to deep anæsthesia without risk. Chloroform, on the other hand, depresses the

heart, and consequently if it is given during shock it is wiser not to push it too far, but merely to benumb sensation without causing complete muscular relaxation.

The **Treatment of the Effects arising from an Overdose of any Anæsthetic** is based on two principles :—1, the establishment of respiration, either natural or artificial, so as to empty the lungs of the vapour contained in the air-cells, and to aid the oxygenation of the blood; and 2, the stimulation of the heart's action, and the maintenance of the circulation.

The treatment to be adopted on the occurrence of dangerous symptoms, or of apparent death from chloroform, is as follows :—

1. The administration of the vapour must be at once discontinued.

2. The tongue should be seized with the fingers, or with forceps, and drawn out of the mouth; and the larynx pushed up so that the glottis may be opened. The tongue must be pulled forcibly forwards, not merely pulled out of the mouth, for the reasons before stated. The finger should be immediately passed down the throat and the glottis examined for the possible presence of vomited food. The pharynx should be freed from mucus with a sponge on a holder.

3. Fresh air should be admitted to the patient by opening doors and windows, and by preventing bystanders or spectators from crowding round.

4. All constrictions should be removed from the patient's throat and chest, and these parts should be freely exposed.

5. Artificial respiration must *at once* be set up, whilst these other measures are being carried out. This should be done by the Sylvester method, which is fully described in the chapter on Asphyxia. Artificial respiration should be commenced by a forced expiratory movement, so as to empty the lung as far as possible of the anæsthetic vapour. Milne Murray has shown that rabbits can be revived from a nearly fatal dose of chloroform with much greater certainty if, as the first step, before commencing artificial respiration, the lungs are exhausted as far as possible by aspiration. To attempt to adopt this plan in man would cause serious loss of time before commencing artificial respiration.

6. Electricity, in the form of faradisation of the phrenic nerve, has been of great use in some cases as an adjunct to artificial respiration. It must be applied methodically as described under the treatment of asphyxia. In using electricity care must be taken not to stimulate the vagus, the effect of which might be finally to inhibit the feeble heart.

7. Nitrite of amyl, when inhaled in health, causes, according to Brunton, flushing of the face, throbbing of the carotids, and a quicker and fuller pulse, with quickened respiration. It causes diminished blood pressure by a general dilatation of the arterioles, and thus relieves the heart. It seems, therefore, from its stimulating influence on the cardiac and respiratory centres, to be indicated as an antidote in chloroform poisoning, whether of the syncopal or asphyxial form: the inspiration of the vapour of ten to fifteen drops of the nitrite unloading the vessels and restoring the heart's action. The administrator should always have at hand, in case of accident, some glass capsules of nitrite of amyl. One of these should be broken into a handkerchief and held over the face while artificial respiration is continued as above described. The head should be placed at the same time as low as possible.

8. As accessory means, friction of the extremities may be employed; a little brandy should be rubbed inside the mouth; and cold water dashed on the face.

9. Tracheotomy or laryngotomy is necessary when the asphyxia is due to the impaction of some foreign body, as false teeth or a gag in the larynx during insensibility, or to accumulation of blood in the pharynx or trachea. It may also be of use when, owing to emphysema of the lungs and rigidity of the chest-wall, artificial respiration cannot be efficiently carried out, but it will be necessary then to blow the air into the lungs and suck it out through the tube either by bellows or by the Surgeon's mouth.

LOCAL ANÆSTHESIA.

Local anæsthesia may be induced in two ways: 1, by cold, and 2, by the use of cocaine.

Cold.—The application of ice and salt, as introduced by J. Arnott, may conveniently be employed in many cases in which general anæsthesia is inadmissible or inconvenient. Local anæsthesia can be produced only in those cases in which the incisions merely implicate the skin and subcutaneous structures, as in opening abscesses, slitting up sinuses, avulsion of toe-nails, or removing small superficial tumours. For such purposes, however, it is extremely valuable. The mode of using the *frigorific mixture* is as follows: About a tumblerful of rough ice is put into a strong canvas bag, and finely powdered with a mallet. It is then poured out on a plate, and half its bulk of salt is quickly mixed with it by means of an ivory or wooden paper-knife. The mixture is then put into a muslin or gauze bag and applied to the part for from five to ten minutes. As soon as the skin becomes white and hard, the incisions may be made without any pain being experienced. The frozen part speedily recovers, no inconvenience resulting.

The **rapid evaporation of highly rectified ether** has been applied by Richardson in the production of cold sufficient to freeze a part, and thus render it temporarily insensible. A fine spray-jet of ether of a low specific gravity is thrown upon the part to be anæsthetised. The skin rapidly becomes white and hard—is, in fact, frozen. This method of inducing local insensibility to pain is more exact and efficacious than that by the frigorific mixture, and is generally preferred. It is applicable in the same class of cases. The ether should be tested before it is used by pouring a little into the hollow of the hand, where, if it is of the proper quality, it will boil violently.

Cocaine is an alkaloid extracted from the leaves of erythroxylon coca. Coca has been known in Europe since the discovery of Peru, the natives of which country have from time immemorial been in the habit of chewing the leaves for the purpose of allaying hunger and supporting strength during prolonged physical exertion. The alkaloid was first extracted by Niemann in 1859, and both he and Hughes Bennett, who investigated its properties in 1872, pointed out the fact that it causes numbness when applied to mucous membranes. No practical use was, however, made of this discovery till 1884, when Carl Köller, of Vienna, demonstrated that the eye could be rendered sufficiently anæsthetic for the performance of almost any operation by putting a few drops of a solution of cocaine on the conjunctiva. The value of this

method was at once recognised, and at the present time cocaine has to a great extent replaced general anæsthetics in ophthalmic surgery. Its use was soon extended to other mucous membranes, and subsequently, by means of hypodermic injections, to the skin and subcutaneous tissue.

Cocaine is most commonly used in the form of a solution of the hydrochlorate in distilled water. The solution should be sterilized by boiling, and kept in a carefully stoppered bottle, otherwise fungoid growths are apt to develop in it. Cocaine can be kept in 1 grain powders which may be dissolved in 10 minims or more of water when required for use. The water must be previously boiled if the solution is to be injected hypodermically.

Cocaine causes a contraction of the small arteries of the part to which it is applied, and thus greatly diminishes the bleeding during an operation, such as removal of a polypus from the nose.

Mode of Employment.—*For the eye;* two or three drops of a 4 per cent. solution are dropped upon the conjunctiva. This is repeated in from three to five minutes, and after about the third application the conjunctiva will be found to be insensible when touched with the finger. The anæsthesia extends to the deeper structures of the eye, so that the operation for cataract or an iridectomy can be performed without appreciable pain. The anæsthesia is accompanied by dilatation of the pupil.

For the mouth or throat.—A 10 or 20 per cent. solution is applied by means of a camel's hair pencil or by a spray apparatus. The anæsthesia commences in about three minutes, and if the application be repeated at intervals becomes complete in from ten to twenty minutes. It passes off in from half to three-quarters of an hour.

For the urethra a 10 per cent. solution is best. It may be injected either directly with a syringe or by means of a catheter to the deeper parts or into the bladder. Its effects are not very certain, as it is difficult to apply it thoroughly to the whole length of the canal, and in the bladder it is apt to be diluted by the urine or prevented from coming in close contact with the mucous membrane by a layer of mucus.

For the removal of small tumours or other minor operations on the skin or subcutaneous tissue it must be applied by hypodermic injection. From 4 to 5 minims of a 4 per cent. solution must be injected at several points in the area which it is desired to render anæsthetic. Anæsthesia is complete in from two to five minutes. This can be ascertained by gently pinching the part with a pair of forceps. It commonly lasts from ten to fifteen minutes. If sensation returns during the operation a few drops of the solution may be poured into the wound, and after a couple of minutes' delay the performance may be continued. If the operation is upon one of the limbs, the duration of the anæsthesia may be greatly prolonged by the application of a tourniquet after one or two minutes have been allowed for the diffusion of the solution. The same effect may be produced, less perfectly, in other parts by surrounding the anæsthetic area with a ring of wood or metal and pressing it firmly down so as to limit the diffusion of the solution.

Cocaine Poisoning.—Several cases have been recorded in which unpleasant and sometimes even alarming symptoms have followed the use of cocaine. The dose in these cases has been very variable, in some little more than a grain of the hydrochlorate. The most common of these effects have been temporary giddiness and nausea, with a sense of oppression on the chest and

a rapid pulse ; these soon pass off and leave no evil effects behind. In more extreme cases, after larger doses, there have been marked pallor of the face, dilated pupils and syncope followed by great prostration on recovery. In one case the patient complained of being unable to see for some hours, and in two, articulation was indistinct for some time. The instances in which these unpleasant consequences have been observed are not yet sufficiently numerous to make it possible to state accurately under what conditions they occur or what is the limit of safety in administering the drug. In one case of extensive tuberculous disease of the kidneys and bladder, 20 grains accidentally given as a draught proved fatal in about one hour. In a case of attempted suicide, 23 grains were taken internally without serious consequences; and, on the other hand, Mayo Robson records a case in which a middle-aged gentleman became aphasic and unable to write half-an-hour after a solution containing one grain had been injected into the nose before the removal of a polypus. The sense of oppression on the chest and the cardiac disturbance are relieved by the inhalation of nitrite of amyl. Alcohol and subcutaneous injections of ether may be given to relieve the faintness.

PERFORMANCE OF AN OPERATION.

In the performance of an operation in private practice the Surgeon must see for himself that the preparations are properly made. The room must be well lighted, of sufficient size and properly warmed. Whenever it is possible the patient should be placed upon a table. An ordinary bed is too low, and its width makes it difficult for both the Surgeon and his assistant to be within easy reach of the wound. The table upon which the patient is placed must be of the ordinary height. The strong deal table usually found in kitchens answers the purpose fairly well. It must be steady on its legs, and if it is not more than three feet wide it will be more convenient. It must be covered with a blanket folded into four layers; another blanket must be provided to place over the patient's body, and pillows must be comfortably arranged for the head. A tray filled with saw-dust, or an old blanket folded very thickly, may be placed on the floor to catch the blood. The friends must be asked to provide in the room a dozen towels, four washing-basins, and two large cans, one of hot and one of cold water, and a slop-pail or foot-bath. A gallon or more of an antiseptic solution, such as carbolic acid lotion of the strength of 1 in 20, should be in readiness, which may be diluted to 1 in 40, for washing the sponges. The necessary amount of the antiseptic solution, according to the extent and nature of the operation, must first be prepared, and the cans of common water must then be removed to one corner of the room, and orders given to the nurse not to touch them ; for, unless she is thoroughly experienced, she is almost certain to use plain water instead of the antiseptic fluid during the excitement of the operation.

The sponges should be brought by the Surgeon himself, and should be properly prepared. Improperly-cleansed sponges have always been justly considered a potent source of infection in wounds. New sponges are apt to be gritty, and should be soaked in a dilute solution of hydrochloric acid for at least twenty-four hours, after which they must be carefully washed. They should then lie for at least twenty-four hours in a 1 in 20 solution of carbolic acid. They must then be squeezed as dry as possible, and put in a glass

vessel covered with a lid to keep out the dust. Before being used they should be again soaked for some hours in carbolic lotion. After an operation the meshes of a sponge are more or less filled with coagulated blood, which mere washing in water will hardly remove. In order to clean it thoroughly, it may be soaked in a strong solution of sulphurous acid; or, after maceration for forty-eight hours in a dilute solution of hydrochloric acid (about ten drops of the strong acid to the ounce of water), and for twenty-four hours in a strong solution of carbonate of soda, it may be well washed in common water, and kept ready for use in a bath of 1 in 20 carbolic acid lotion. A simpler plan, and one which experience has shown to be very efficient, is to wash the sponges for ten minutes in very hot water with a large amount of soft soap. The soap must be well washed out by repeated rinsing in fresh hot water, after which the sponges may be placed in the carbolic lotion. In many cases sponges are advantageously replaced by pieces of salicylic or sal-alembroth wool moistened with some antiseptic solution and squeezed as dry as possible.

Before commencing an operation, the Surgeon must look over his instruments, comparing them, if the operation be complicated, with a list previously made out; he must see that they are arranged in the order in which they are wanted. They should be placed in a flat dish filled with an antiseptic solution. For this purpose nothing is better than a 1 in 20 solution of carbolic acid, which has no injurious effect on the instruments. This method of sterilizing the instruments seems practically efficient, but some Surgeons prefer to expose them to super-heated steam in a specially constructed chamber, and use knives with metal handles which will not be injured by the heat. Much of the successful performance of an operation depends on the attention and steadiness of the assistants. Of these there should be enough, but not too many. In all capital operations three or four will be required; one for the administration of the anæsthetic, another to command the artery, a third immediately to assist the Surgeon, and the fourth to hand sponges, instruments, &c. The duties of the assistants should be performed in silence, and each man must carefully attend to his own business, and not neglect this, as is too often done, in his anxiety to see what the Surgeon is about. There should be no unnecessary talking when once the patient is on the table; the Surgeon's directions ought to be conveyed by a brief word or two, or by a sign with the hand.

Fig. 3.—Bistoury held perpendicularly.

The incisions for the operation should be carefully and properly planned, so as to give sufficient space with as little mutilation as possible; but it must always be borne in mind, that although a needlessly long incision may lead to unnecessary disfigurement, it does not add materially to the danger of the patient, while too small an incision hampers the Surgeon and greatly increases his difficulties, especially in the arrest of hæmorrhage.

Incisions may be made by cutting from without inwards, or from within outwards, or subcutaneously. The most convenient instrument for all ordinary

incisions is the scalpel. This should be set on a smooth ebony handle, which is less slippery than ivory or steel when wetted with blood, and admits greater delicacy of touch; it should be light in the blade, nearly straight-backed, and slightly bellied in the cutting edge. The heel should be as wide as the widest part of the blade, and there should be no constriction where it joins the handle. When very free and extensive incisions are required, as in the removal of large tumours, a Liston's bistoury, of proper size and shape, is a very convenient instrument (Fig. 3). For a subcutaneous incision, a very small narrow-bladed knife is required.

The ordinary scalpel is held in two ways: first, like a pen (Fig. 4); secondly,

Fig. 4.—Scalpel held like a pen.

like a dinner-knife (Fig. 5). The former position is that universally adopted in dissecting the dead body, and the habit of always holding the knife in this way is one of the first faults which a student commencing operative surgery has to correct. In dissection, also, the student habitually turns his knife from

Fig. 5.—Scalpel held like a dinner-knife.

the deep parts towards the skin, so that any slip of the knife may not injure the subcutaneous structures which it is his object to preserve. In raising flaps in the living body, the reverse must be the rule, as, if the skin and subcutaneous tissues are scored by the knife, the flap will certainly slough. Every teacher of operative surgery has experienced how difficult it is to correct this most dangerous habit in young operators. In making an ordinary incision from without inwards, as in the removal of a tumour, or in cutting down upon an artery in its continuity, the skin must be put gently on the stretch, and the knife entered perpendicularly (Fig. 3), so as fairly to penetrate the subcutaneous fat; the handle may then be lowered, so that the incision is continued with the belly of the knife. This may be done by drawing the knife steadily along, if the edge is good and the tissues are not particularly resistent; more often, however, a slight rapid sawing movement is required. In bringing

the knife out again, the handle should be raised so that there may be no "tailing," but that the incision may be as nearly as possible of equal depth throughout. The bad habit of gradually losing length as the incision is deepened, so that, for example, a four-inch incision through the skin is reduced to three at the fascia, should be carefully avoided. An ordinary wound is gradually deepened by simply drawing the knife along it, with its edge directed downwards and parallel to the incision, until the deep fascia is reached. As the wound is deepened it is, if necessary, held open by an assistant with blunt hooks or spatulæ. The division of the deep fascia often requires care, as important structures may lie beneath, which it is necessary to avoid. It is done therefore in one of two ways. It may be picked up with a pair of dissecting forceps, and a small hole carefully made in it, through which a

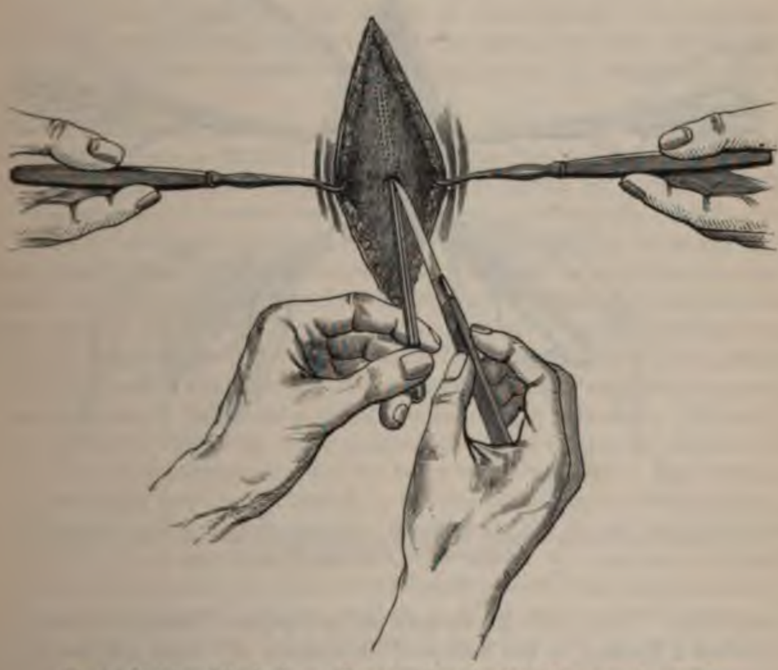

Fig. 6.—Division of the fascia on a director. Blunt hooks holding open the wound.

director may be inserted, upon which it may be divided, the back of the knife being turned downwards (Fig. 6); or, the small hole having been made in it, the point of one blade of the forceps may be introduced, and the fascia seized and raised slightly from the parts beneath. The side of the knife then being turned downwards, the portion of fascia raised in the forceps is divided in the direction of the incision in the skin, only the last half-inch of the knife being used. A fresh hold is then taken with the forceps, and another piece of the fascia divided in the same way (Fig. 7). With a little practice it is easy in this way to make a clean linear incision through the fascia. It is a much safer plan than that of using a director, as nothing is divided but that which is raised by the forceps, whereas in pushing a director blindly under a fascia its point may pass beneath something which it is not intended to cut.

Where the tissues are very lax beneath the fascia, it is often a convenient plan to guide a probe-pointed bistoury on the forefinger of the left hand, instead of using a director. The finger is the best director when it can be used, as it can be guided more or less by sensation. Occasionally in deepening a wound through very loose structures, amongst which important vessels may lie, as in removing tumours from the root of the neck or the axilla, the Surgeon may prefer to make use of a blunt instrument, and to tear the tissues instead of

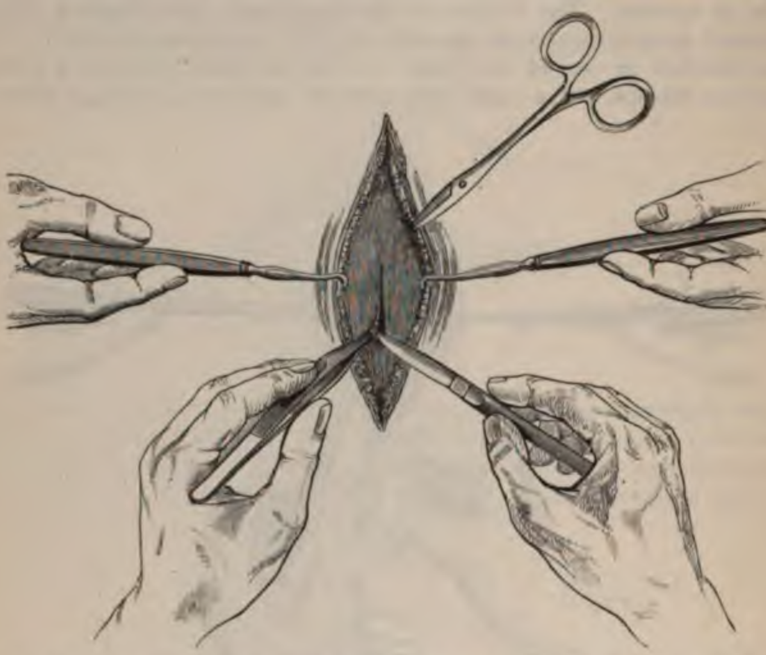

Fig. 7.—Dissection through a fascia. Spencer Wells's forceps on a bleeding vessel. Blunt hooks holding open the superficial wound.

cutting them. With this view he may use two pairs of forceps, or one pair of forceps and a director, or the handle of the scalpel. He must not, however, be tempted to use these forcibly or rashly, as by so doing much mischief may be produced. He must work methodically, picking up what he intends to tear with the forceps, and being careful to tear only what he has thus seized. In some cases a properly cultivated finger-nail or thumb-nail will be found a most useful instrument.

PREVENTION OF HÆMORRHAGE DURING OPERATIONS.

In every operation involving the use of the knife, loss of blood is the primary danger to be guarded against. This may be prevented most conveniently in the extremities by the use of the tourniquet or the elastic band, or by an assistant compressing the main artery of the limb. If the seat of the operation be such as not to admit of this, the assistant may compress the bleeding vessels as they are divided during the operation ; and as soon as it is

concluded, he can remove his fingers from them, one by one, to admit of their being ligatured or twisted. This plan has, however, the disadvantage of occupying the assistant's hands at a time when they may be wanted to help the Surgeon, and it will be found more convenient if the vessels be seized in a pair of catch-forceps of the pattern recommended by Péan and Sir T. Spencer Wells (Fig. 7). These forceps have scissor handles, and the grasping extremity is roughened by rather deeply cut transverse teeth. They can be applied instantaneously, and their hold is extremely firm, and from their length and weight it is easy for the assistant to keep them out of the wound during the operation, while at the same time his fingers are free to help the operator. At the conclusion of the operation, it will frequently be found that their pressure has permanently arrested the bleeding from the vessels to which they have been applied. Their action in this respect will be more fully described in the chapter on the Arrest of Hæmorrhage. As a means of temporarily arresting bleeding during an operation, they have proved of the greatest possible value, especially in operations about the head and neck, and abdomen.

The Tourniquet and its Application.—The older Surgeons from the time of Archigenes, a Roman who lived in the first century, bound a tight narrow band, called the "fillet," round a limb during an amputation. The fillet was intended to serve three purposes—first, to steady the muscles during the incision; secondly, to numb the limb; and thirdly, to arrest the flow of blood; but it seems to have but imperfectly succeeded in producing the desired results. In 1674, Morel, a French Surgeon, improved the fillet by introducing a piece of stick beneath the band, by means of which it could be twisted up and efficiently tightened. To protect the limb from being bruised, he introduced compresses beneath the band; and to ensure the more complete compression of the main artery, he placed a rolled bandage along its course. Beneath the knot, to save the skin from being pinched, he placed a piece of leather or thick paper. To this apparatus, he gave the name of "tourniquet." The tourniquet in this primitive form is still useful, in the absence of any other appliance, for the temporary arrest of hæmorrhage. A round pebble, or any hard body about the size of a hen's egg, may be rolled in the middle of a pocket-handkerchief and laid over the artery, the ends of the handkerchief being knotted round the limb, and then twisted up tightly with a piece of stick. In the hands of an ignorant person, however, the pebble would be better left out, as if it were not applied in the proper place, it might serve merely to relieve the main artery from pressure. The piece of folded paper beneath the knot should never be omitted, or the agony caused by the pinching of the skin would be more than the patient could bear.

The screw tourniquet which replaced Morel's imperfect apparatus, was invented by the French Surgeon Petit in 1718; and, although the details of its mechanism have undergone improvements, the instrument used in the present day is essentially the same (Fig. 12). It may be applied with or without a pad over the artery. If a pad be used, it is best made of a common roller, from two and a half to three inches wide; of this a few feet must be unrolled. The roller is then placed longitudinally on the artery, and the unrolled part carried twice round the limb so as to keep the pad in position, but care must be taken in doing this not to constrict the part sufficiently to cause venous engorgement. The tourniquet is then applied, and the band

buckled with sufficient tightness to keep it in its place; but the instrument should not be screwed up until the moment of the operation. It should then be tightened rapidly, so as to avoid as much as possible the congestion of the limb that always occurs when a tourniquet is applied. The first effect of the tightening of the tourniquet is to compress the large veins; the second, to arrest the flow of blood through the arteries: hence the more slowly it is screwed up the greater will be the venous engorgement of the limb. The blood that flows from the limb during an amputation, when the tourniquet is applied as above described, is almost entirely venous, coming from the lower part of the member.

A screw tourniquet may be equally well applied without a pad (Fig. 12); but it is then necessary to put a piece of card, folded paper, or leather, beneath the screw to save the skin from being pinched. The pad has the disadvantage of being liable to slip, and if not very accurately applied, it tends rather to protect the artery from pressure than to compress it. The screw tourniquet is now almost abandoned in favour of the simple elastic band. It is, however, a useful instrument when the Surgeon is short of skilled assistants, and especially in wounds of large arteries, in which an occasional relaxation of the tourniquet is required to guide the operator to the injured vessel.


Fig. 8.—Esmarch's Tourniquet applied to Shoulder.

Compression by Elastic Tubing or Bandage.—The circulation through a limb may be completely arrested by two or three turns of an elastic bandage applied with moderate firmness. The bandage may then be secured by a knot or by a pin. During the Franco-German War, the field tourniquet served out to the German army consisted of nothing more than a narrow elastic bandage about one inch in width and three feet long. Esmarch, of Kiel, introduced as a substitute for the bandage, a piece of india-rubber tubing about three-quarters of an inch in diameter and two feet in length, having a hook fixed to one end and an eye to the other. This is stretched and wound firmly and rapidly round the limb two or three times. It often happens that the hook does not meet the eye exactly as it is wanted to, so that either an extra turn of the tube must be put round the limb, or the former turns must be unduly relaxed. This may be obviated by replacing the hook and eye by two pieces of stout tape, bound on to the ends of the india-rubber tube. The tube can then be applied with exactly the amount of force required, and secured by tying the ends of the tape together. It must be remembered that in applying the band, enormous pressure is easily obtained by a few turns one over the other, so much so, that in situations in which the chief nerves lie very close to the bones, as in the arm, symptoms of paralysis, sometimes lasting for weeks, are recorded as having resulted from its use. Such accidents are more likely to occur if the narrow tube is used, than if the constriction be made by an elastic bandage. The latter should therefore be preferred where it can be conveniently applied.

In certain regions special plans have to be adopted in the application of the elastic tourniquet.

In excisions or amputations of the **shoulder**, the india-rubber tube must be very forcibly stretched and applied round the shoulder, the lower part of the turn being high in the axilla, so as to compress the artery against the neck of the scapula, and the upper part as far as possible internal to the end of the clavicle and the acromion process. To prevent its slipping, a piece of bandage should be put beneath it both in front and behind at the time it is applied, by means of which an assistant may hold it in position (Fig. 8).

In operating upon the **upper part of the thigh**, the india-rubber tube must be of sufficient length to go round the limb and the pelvis. The middle of the tube is to be applied to the front of the thigh immediately below the groin; the two ends are then to be carried forcibly round and brought up to the front again, where they cross, and are afterwards passed round the pelvis immediately below the crest of the ilium (Fig. 9).

Fig. 9.—Esmarch's Tourniquet applied to Thigh.

In amputation at the **hip-joint**, a long piece of bandage must be laid upon the middle of the groin in the line of the limb, and a similar piece behind, over which the tube is to be applied, so that by pulling on the ends of the bandage any slipping of the band may be prevented during the operation. The middle of the tube is to be placed in the perinæum, and the ends pulled forcibly outwards and crossed as high above the trochanter as possible, and afterwards carried round the pelvis immediately below the crest of the ilium (Fig. 10). If the bandage is applied with sufficient force, it is unnecessary to put a pad over the artery. In Fig. 10 the patient is lying on his side with the right thigh flexed, in the position for an oval amputation at the hip-joint.

Fig. 10.—Arrest of Hæmorrhage in Operations on the Hip-joint. The dotted line is the incision for the oval amputation at the hip-joint.

Fig. 11.—Esmarch's Band applied for Operations on the Penis or Scrotum.

In operations upon the **penis or scrotum**, a piece of bandage should be laid along the spine behind and brought forward to the scrotum in front.

The middle of the tube is then placed in the perinæum, and the lower end of the bandage turned up over it. The ends of the tube are next brought forwards forcibly, crossed on the pubes, and afterwards carried round the pelvis, passing on each side mid-way between the trochanter and the crest of the ilium. The two parts of the bandage are then tied together, thus attaching the loop of the tube surrounding the scrotum to the part which passes behind ; any slipping of the tube during the operation is thus rendered impossible (Fig. 11).

Bloodless Methods.—Various devices have been employed to diminish the loss of blood during operations on the extremities, and at the same time to get rid of the blood which otherwise fills the wound, and more or less conceals the steps of the operation, even when a tourniquet has been applied. The oldest of these is bandaging the limb firmly up to the level at which the tourniquet is applied, before tightening the screw. This is not very efficient, especially when a pad is placed over the main artery beneath the band of the tourniquet. Lister has shown that the limb may be rendered bloodless by simply elevating it as high as possible for about one minute, and then rapidly applying an elastic band or a screw tourniquet without a pad. To hasten the emptying of the blood-vessels the limb may be rubbed firmly in the direction of the circulation (Fig. 12). By experiment he has further shown that this is brought about not only by the emptying of the veins, but by the contraction of the arteries which occurs when the limb is placed in the elevated position. Esmarch has obtained the same result by applying an elastic bandage spirally from the distal extremity of the limb upwards to the point at which the tourniquet or elastic band is applied (Fig. 13). On removing the elastic bandage from below the tourniquet, the limb will be found to be absolutely bloodless, even the bones very frequently yielding no blood on being cut. With the exception of the elasticity of the skin and the retraction of the muscles, the operation now resembles one on a dead body. In this state, all vessels of any size can be seen and tied before the tourniquet is removed. The anæmia thus induced is followed on removing the tourniquet by hyperæmia, corresponding in intensity to the time that the limb has been kept bloodless, and very free oozing consequently sets in, which often takes some time to arrest by means of cold and exposure to the air. Thus it may happen that the patient loses as much blood as if Esmarch's method had not been employed. Esmarch, however, subsequently adopted a plan by which most operations on the extremities can be rendered actually bloodless. He first secures every vessel visible on the surface of the wound, and then, having put in the drainage-tubes and introduced the sutures, he applies a dressing com-

Fig 12.—Lister's Method.

posed of antiseptic gauze surrounded by cotton-wool impregnated with salicylic acid, which is moderately firmly bandaged to the part. The limb is then placed in an elevated position, and finally the elastic tourniquet is removed. The elevated position is maintained for at least half an hour or an hour. In 12 cases of amputation and 56 excisions in which this plan was tried, it succeeded perfectly. In 148 operations for necrosis, it was necessary to remove the dressing on account of hæmorrhage in six cases only.

Various objections besides the subsequent oozing have been raised to Esmarch's bloodless method. It has been stated that it causes sloughing of the flaps and increases the tendency to secondary hæmorrhage after large amputations, by unnaturally augmenting the proportion of blood in the body, and so giving rise to increased arterial tension. Neither of these statements is supported by experience. A more rational objection against it is, that when the limb is infiltrated with the products of inflammation, or when perhaps clots exist in the veins, these may be driven on into the circulation by the application of the elastic bandage. Although no case of such an accident has been recorded, it would be safer when such conditions exist to empty the limb of blood by the simpler plan of elevation as before described. The same plan is also better employed in cases of cancer or sarcoma, in which the danger of

Fig. 13.—Esmarch's Method.

dislodging particles and driving them into the circulation would be very considerable. The advantages of the bloodless method of operating, however, especially in diseases of bones and joints, far outweigh any supposed disadvantages.

It is difficult to say how long complete arrest of the circulation through a limb may be maintained by the elastic band or the tourniquet without danger of gangrene. It must necessarily vary according to age. Esmarch's method has been used for about three hours without any evil result.

Compression of the Main Arterial Trunk is in the present day employed only as a temporary expedient before a tourniquet can be applied, or immediately after its removal, while a few vessels before invisible are being secured, or in those situations in which the application of a tourniquet is impossible. It is far safer to trust to an instrument than to the hands of an assistant, however steady and strong. When the tourniquet is applied with sufficient tightness, the whole circulation through the limb is arrested ; but this can never be done by the compression of the main trunk alone, as the collateral vessels still convey blood into the limb. Then again, if the operation be unexpectedly protracted, the fingers of an assistant may tire, and the steadiness of their pressure be relaxed. For these reasons Surgeons invariably employ the tourniquet in amputations ; and even Liston, who at one period of

his career discarded this instrument, commonly employed it during the latter years of his life.

The points chosen for the compression of arteries are those at which the vessel is comparatively superficial, and is placed over some bone against which it can be pressed. The following are the chief arteries which the Surgeon may be called upon to compress :—

The **common carotid** can be felt pulsating in front of the sterno-mastoid, and is best compressed by pressing the thumb directly backwards towards the vertebræ opposite the cricoid cartilage (Fig. 14). To steady the hand, the fingers should grasp the back of the neck. If the pressure be applied below the transverse process of the sixth cervical vertebra, the vertebral artery will be compressed at the same time as the carotid.

The **facial artery** is easily compressed against the jaw, where it lies quite superficially immediately in front of the anterior border of the masseter. The fingers may be placed on the opposite side of the jaw to steady the hand, and if necessary, the forefinger may compress the opposite artery. In operations

Fig. 14.—Compression of the Carotid.

Fig. 15.—Compression of both the Facial, right Temporal, and right Subclavian Arteries.

upon the nose and lips the assistant may stand behind the patient and compress both vessels while he holds the head (Fig. 15).

The **temporal artery** is compressed where it can be felt pulsating immediately in front of the ear (Fig. 15).

The **subclavian artery** may require compression in the third part of its course in operations in the axilla, or on the shoulder-joint, or in amputations high up in the arm. If digital compression be attempted the fingers should be placed behind the lower part of the neck, with the palm of the hand on the ridge formed by the trapezius. The thumb is then forcibly pressed upon the artery, where it lies on the first rib, immediately external to the outer border of the sterno-mastoid and opposite the most prominent part of the clavicle (Fig. 15). As considerable force is required efficiently to compress this artery, the fingers of the opposite hand may be pressed upon the thumb which is upon the vessel. The patient's head should, if possible, be inclined towards the side on which the artery is being compressed, so as to relax the cervical fascia. As ...rce required is often so great that the assistant is apt to become fatigued ...lax his pressure, it is better to compress the artery with some mechanical ...rance. The most commonly employed is a large door-key. The ring of

the key is wrapped round with a strip of lint, so as to prevent it from injuring the patient; the other end is also well padded to protect the Surgeon's hand. The padded ring is then pressed forcibly down upon the artery in the situation before described (Fig. 16).

In cases in which the clavicle is pushed up by an aneurismal tumour, Syme recommended that an incision should be made above the clavicle through the skin and deep fascia, so that the fingers of the assistant might bear almost directly upon the vessel, which would thus be more securely compressed.

Fig. 16.—Compression of Subclavian with key, and Digital Compression of the Brachial.

The **brachial artery** is best compressed by grasping the limb opposite the middle of the arm, so that the tips of the fingers are placed immediately internal to the edge of the biceps, and thus press the artery against the bone while the thumb rests against the humerus on the opposite side (Fig. 16).

The **radial and ulnar arteries** frequently require compression while the Surgeon is searching for a wounded vessel in the palm of the hand; and the assistant must, under these circumstances, steady the hand as well as compress the vessels. He will best do this by grasping the lower part of the forearm firmly with both hands, his fingers being at the dorsal aspect, and his thumbs pressed upon the arteries immediately above the wrist; on the radial, at the point at which it is commonly felt as the pulse, and on the ulnar, at the outer border of the tendon of the flexor carpi ulnaris (Fig. 17).

Fig. 17.—Compression of the Radial and Ulnar Arteries.

Compression of the abdominal aorta is required in some cases of amputation at the hip-joint or high up in the thigh, and in operations for aneurism of the iliac arteries, or the branches of the internal iliac in the buttock. The point at which it is most conveniently compressed is immediately above its bifurcation. The bifurcation of the aorta takes place on the body of the fourth lumbar vertebra, a little to the left of the middle line; superficially this corresponds to a point a little below and to the left of the umbilicus, and on a level with the highest part of the iliac crest. In compressing the aorta, therefore, the pressure should be applied a little above and to the left of the umbilicus. In children, and very thin subjects, the aorta can readily be compressed with the hand in this situation, but the force required is so great that it is impossible for it to be maintained for any length of time. In the absence of any other instrument, Esmarch recommends the following plan:—A common roller bandage about two and a half inches wide and eight yards long is to be rolled round a stick about the thickness of the

thumb and nine inches long. The pad thus formed is held in the proper position by the ends of the stick, while several turns of elastic bandage are passed round the body so as to press it forcibly against the spine. After it is applied an assistant must continue to hold the pad in position by means of the stick. An objection common to this and to all other elastic appliances for compression of the aorta is, that should the patient vomit, the forcible contraction of the abdominal muscles will lift the pad from the aorta and relax the compression. It is better, therefore, whenever possible, to use the instrument known as Pancoast's or Lister's Aortic Tourniquet (Fig. 18). This consists merely of a large horse-shoe clamp, one end of which is expanded and padded so as to fit the spine, and the other receives a screw which presses down a pad of sufficient size to compress the aorta with certainty. Lister states, that from examination of a considerable number of bodies, he has found that the aorta is as often in the middle line as to the left of the spine, and consequently it is better always to feel for the pulsation before applying the pad, taking the highest point of the crest of the ilium as the level of the bifurcation, and ignoring the umbilicus altogether. If the pad be placed exactly on the vessel, a comparatively slight degree of pressure is required to arrest the flow of the blood, but should it be misplaced the Surgeon may be tempted to use an amount of force which might prove injurious to the soft parts and intestines beneath the pad. In order still further to avoid injury to these parts, it is as well to place a soft hollow sponge beneath the pad. The instrument, when properly applied, interferes but slightly, if at all, with the flow of blood through the vena cava.


Fig. 18.—Lister's Aorta Compressor applied.

Compression of the common iliac may easily be carried out by the application of the aortic tourniquet over the line of the artery; that is to say, in the upper third of a line drawn from a little to the left of the umbilicus at the level of the highest point of the crest of the ilium to a point midway between the symphysis pubis and the anterior superior iliac spine. Richard Davy, of the Westminster Hospital, has invented a plan of compressing this artery by means of a straight lever of wood introduced into the rectum, which usually answers very well. The lever should be about two feet in length, smooth and round, and shaped something like a poker. About two ounces of olive oil having been injected into the rectum, the end of the lever is introduced to such a distance that its point comes to lie over the artery in the groove between the last lumbar vertebra and the psoas muscle. By raising the handle of the lever and bringing it against the opposite thigh, the artery is most efficiently compressed, the tissues of the perinæum acting as the fulcrum.

Compression of the external iliac can be carried out with certainty only immediately above the groin, as above that point it is easily pushed over the brim of the pelvis into such a position as to escape pressure. If it be desired to compress it, this may be done either with the fingers or by placing a roller

bandage across the line of the artery, and securing it first by a few turns of a common bandage, passing in a figure-of-eight round the upper part of the thigh and the pelvis below the crest of the ilium, over which must be put a few turns of an india-rubber bandage.

Compression of the femoral artery immediately below the brim of the

Fig. 19.—Pressure with Thumbs. Application of Tourniquet to Femoral Artery.

pelvis (Fig. 19) is commonly resorted to for the temporary arrest of hæmorrhage from any part of the lower limb. The Surgeon stands by that side of the patient on which the vessel is to be compressed, with his back towards the patient's head and his body inclined over the pelvis. He then grasps the limb firmly with both hands, the fingers of one hand obtaining a hold on the mass of the adductor muscles, and those of the other on the posterior border of the trochanter major. His two thumbs are placed one over the other upon the artery at a point immediately below Poupart's ligament, and exactly midway between the symphysis pubis and the anterior superior iliac spine. Instrumental compression in this situation is employed only in the treatment of aneurism, and will be described with that disease.

Fig. 20.—Compression of Tibials, and mode of holding the foot in operations requiring an incision in the sole.

The popliteal artery is too deeply situated to be compressed with advantage. In bleeding from a point below the knee and above the ankle, it is better to apply the pressure to the femoral artery at the groin.

The anterior and posterior tibial arteries at the ankle may conveniently be compressed during an operation on the foot (Fig. 20). The assistant may,

at the same time, steady the foot, and hold it in a convenient position for the Surgeon. The limb being bent at a right angle, the assistant puts the patient's knee in his axilla; he then grasps the limb firmly with one hand above the ankle, and with the finger and thumb compresses the vessels. The posterior tibial is to be compressed with the tips of the fingers one finger's breadth behind the internal malleolus, and the anterior tibial with the thumb in front of the ankle at a point exactly midway between the two malleoli, that is to say, a little to the outer side of the middle line.

CONSTITUTIONAL EFFECTS OF OPERATIONS.

Every operation of any importance is followed by a certain degree of *shock* as indicated by a low temperature and a small and frequent pulse. As the shock passes off the temperature usually rises slightly above the normal point, the pulse becomes fuller and there is some thirst. This *traumatic fever*, if moderate and confined within certain limits, can scarcely be looked upon as a morbid condition; and unless it is kept up by some unhealthy state of the wound, by the presence of decomposing matter, or by pent-up discharges, it completely subsides by the third day. If the thermometer remain below 100° F. no anxiety need be felt on this score.

The **Local Treatment of Operation-Wounds** differs in no respect from that of accidental wounds, and will be treated of in the chapter on the treatment of such injuries.

The **Constitutional After-Treatment** of operations demands as much attention on the part of the Surgeon as the management of the wound itself. Immediately after the operation, and before the effects of the anæsthetic have passed off, the patient should be comfortably arranged in bed, with the clothes supported by a cradle, or other contrivance, away from the part implicated.

When the patient has fully recovered from the anæsthetic, if he is in much pain a hypodermic injection of morphia or a dose of laudanum may be given, but this should be avoided if possible, as it may cause vomiting. The patient should always be kept perfectly quiet.

The **Diet after the Operation** must depend upon the constitutional condition of the patient, his previous habits, his age, and upon the severity of the operation, and the septic or aseptic state of the wound.

As a general rule it is unwise to hurry the reaction after an operation by the administration of stimulants. A slow reaction gives more time for the perfect closure of the smaller vessels which have not been tied, and thus diminishes the chance of intermediate hæmorrhage. It is only in dangerously severe shock that stimulants are required. After minor operations the patient, if otherwise healthy, may be allowed his ordinary diet somewhat diminished in quantity and without stimulants. In more severe operations the Surgeon must be guided by the course taken by the wound and by the temperature. During the first two or three days there is usually some slight elevation of temperature, and the appetite is impaired by the anæsthetic and the sudden confinement to bed. During this period the patient will seldom care for solid food, and he should be restricted to farinaceous slops, beef-tea, soups, and light puddings, without stimulants. If the wound runs an aseptic course, the temperature will usually fall to normal by the third day; the appetite then returns, and the patient may be allowed to resume his ordinary diet,

limiting himself to plain dishes, and restricting the quantity while he is taking no exercise. Stimulants are not needed in such cases, but if the patient is in the habit of taking them with his meals he may be allowed to do so, the quantity being limited. No stimulants should be allowed between meals.

In cases in which the wound runs a septic course, with abundant suppuration and high fever, a very different diet may be necessary. Solid food cannot be taken under these circumstances, and if swallowed would not be digested. Strong beef-tea, thickened with the white of an egg or a small quantity of arrow-root, good soups, milk, milk and egg, milk and arrow-root, and other fluid foods can alone be taken, and in order to supply the necessary fresh vegetable element in the diet the patient may be allowed to quench his thirst with still lemonade. It is not my intention to enter upon the question of the use and abuse of alcohol as an article of diet; as a medicinal agent in severe surgical cases there can be no doubt of its utility. It can be used in three ways. In mild cases, without severe fever, it may promote the enjoyment of food and good digestion in those accustomed to its use. For this purpose good wine or well-brewed beer may be taken with meals, that stimulant being given to which the patient is accustomed in a state of health. In old and weakly people its administration in a dose sufficient to cause some increased force and frequency in the heart's action is most useful in preventing hypostatic congestion of the lungs and stagnation of blood in the extremities; conditions which not unfrequently play an important part in the causation of death. For this purpose a glass of one of the stronger wines or an ounce of good brandy or whisky may be given two or three times a day. Lastly, alcohol may be made to act as a food. It is not a true food, as there is no mechanism for storing it in the body, and if given in any but the smallest doses a large proportion comes off unaltered by the breath and in the urine, but if administered in very frequently repeated small doses it is completely consumed, coming off as carbonic acid and water, a process which is necessarily accompanied by a liberation of force in the body. It may often be given in this way at a time when the patient is incapable of taking or digesting any ordinary food, and is at the same time rapidly consuming his own tissues, as during severe septic fever. Given in this manner it diminishes tissue waste, and may maintain the patient's strength till the crisis of the fever is passed or the cause removed, or the effects of shock or loss of blood rallied from. By dilating the vessels of the skin it also aids in reducing the temperature. When stimulants are given with this intention, the dose should not exceed 1 drachm of proof spirit. It must be given at regular intervals, the frequency varying with the state of the patient. It may be necessary to administer it every ten minutes. The spirit must be of the best quality, and if really good brandy or whisky cannot be obtained rectified spirit diluted with water should be used. In less critical conditions the stimulant may be given with liquid food at frequent intervals. I have seen many patients saved by the free administration of brandy and wine with eggs and beef-tea from an early period after the operation.

In all this the Surgeon must be guided by the patient's pulse, tongue, and temperature, and nothing requires greater judgment than the administration of stimulants according to these particulars. Nothing can show greater want of judgment than indiscriminate "pouring in of brandy," often to the exclusion of food, under the idea that "alcohol gives strength."

It is of the utmost importance that the bowels should be kept regularly open, as constipation is often a great trouble from the sudden confinement to bed and loss of exercise. It is needless again to insist on the great importance of general cleanliness and ventilation.

The **remote effect** of the major operations is a subject that requires investigation. Do people who have undergone any of the greater operations, and who have recovered from the immediate effects, as a rule, live as long as those who have not sustained a mutilation? I am disposed to think that they do not. When we reflect on the number of persons who, before the age of thirty, suffer amputation of one of the limbs for injury, it is remarkable how seldom one sees an old person in a hospital or elsewhere, who has lost a limb in early life. I am, of course, speaking only of amputations for injury; for those who have undergone this operation for strumous affections or malignant tumours, frequently die early from recurrence of the disease in other parts of the body. So also with respect to lithotomy. Very many boys are cut for stone every year and recover; but I scarcely recollect to have met with a middle-aged adult who had been operated on in childhood.

The various Special Operations will be considered when treating of the several Injuries and Diseases for which they are required; but, as Amputations do not readily fall under any special head, being required for a great variety of different conditions, it will be more convenient to consider them here.

CHAPTER II.

AMPUTATIONS AND DISARTICULATIONS.

THE term *Amputation* means the separation of a part of the body. It is most commonly applied to the removal of a limb, but sometimes also to that of other parts, as the breast or penis.

The frequency of amputation of the limbs has much lessened of late years; less severe modes of treatment being now followed in many cases of diseased joint and of compound fracture. Still amputations are among the most frequent operations in surgery, and will continue to be so as long as the human body is liable to severe mutilations, to gangrene of the limbs, and to incurable diseases of the bones and joints. It has been somewhat the fashion to decry amputation, and to speak of this operation as an opprobrium to surgery. "Any blockhead," says Kirkland, "can amputate a leg." Yet I cannot admit that the removal of a limb is an operation of less merit than any other, when adopted after all other means have failed, in curing the diseased part, or in saving the patient's life from danger. Surely, it is rather a subject of just pride than the reverse that the Surgeon is able to save the whole of the body by sacrificing a useless limb. It is true, of course, that no amputation should be undertaken except as a last resource and after due consideration; for, as John Woodall quaintly says, "it is no small presumption to dismember the image of God." In the performance of an amputation, also, much dexterity may be displayed; and there is great scope for skill in the constitutional treatment of the patient both before and after the operation.

Amputations may be required for *Injury* or for *Disease*. If performed for injury within the first few hours after the accident before traumatic or septic fever has set in, the amputation is termed *Primary*; if during the high febrile disturbance which accompanies septic inflammation and suppuration for the first eight or ten days, it is termed *Intermediate*; if after the subsidence of the fever, *Secondary*. Most commonly the term "intermediate" is not used, and all amputations for injury performed after the first twenty-four hours are classed as secondary.

The amputation of a limb is generally performed through the continuity of a bone: when done at a joint, it is called a *Disarticulation*.

History.—Amputation for diseases of joints and bones, or for the immediate effect of injury, is an operation of comparatively recent date; for the older Surgeons, with few exceptions, undertook the removal of a limb for gangrene only. So much was this the case, that in the works of many of the older writers the only mention of amputation is in the treatment of gangrene. In the works of Hippocrates (about 400 B.C.) in the book on Articulations, the following is the treatment recommended in gangrene:—"Those parts of the body which are below the boundaries of the blackening are to be removed at the joint, as soon as they are fairly dead and have lost their sensibility; care being taken not to wound any living part." Such a performance can

scarcely be called an amputation. Celsus, who lived at the commencement of the Christian era (B.C. 25 to A.D. 45) encouraged a bolder line of practice. The operation of amputation as described by him was thus performed: A deep incision was made to the bone between the living and the dead tissues, encroaching rather on the living than leaving any of the dead. When the bone was reached, the sound flesh was drawn back from it, and the saw applied as high as possible. The edges of the skin were then brought down, and it was recommended that the covering should be lax, that it might as nearly as possible cover the bone. As, however, Celsus advises that the part which the skin did not reach should be dressed with lint and a sponge squeezed out of vinegar, it is probable that in many cases at least the covering was not sufficient to make a perfect stump. Celsus was acquainted with the use of the ligature, and it is possible, therefore, that the vessels were secured by that means, but no distinct mention of it is made in his description of the operation. Whatever the method may have been that he adopted for arresting hæmorrhage, it seems not to have been very efficient, for he tells us that the operation was attended by very great danger, the patients often dying during its performance, either from hæmorrhage or fainting. "But," he says, "in this it is not to be considered, whether the remedy is very safe, for it is the only one we have." Towards the end of the first century Archigenes (A.D. 48—117), a Greek practising in Rome, whose writings are quoted by Oribasius, extended the field of the operation, recommending it in cases of severe wounds, cancer and incurable ulcers. He attempted to arrest bleeding during the operation by the use of the "fillet," a band bound tightly round the limb. He also recommended tying the large vessels before dividing them, but the exact method in which he did it is not clear. Heliodorus, who flourished about the same time, performed the operation in two stages, dividing first those parts that contain no large vessels, then sawing the bone, and finally cutting through the remaining tissues, with the large vessels to which he applied the actual cautery. Galen (A.D. 131—201), who also practised in Rome, describes the operation only as performed for gangrene. He relapsed somewhat towards the practice of Hippocrates, for although cutting in the line of demarcation between the dead and the living tissues, he recommended the operator to encroach rather on the former than the latter and afterwards to apply a cautery to such dead tissue as was left behind. From this time to the thirteenth century no important change took place in the method of operating, Galen's practice being generally adopted. During the whole of this period amputation seems to have been practised chiefly, if not solely, for gangrene, and although the use of the ligature was frequently recommended for accidental wounds of arteries, the cautery was exclusively used in amputations. In the thirteenth century Theodoricus (1205—1298) repeated the instructions given by Celsus, but the operation seems not to have found much favour, for in the following century Guy of Chauliac, although he described the operation by the knife, expressed his preference for a method of his own invention, which consisted in strangulating the limb by plasters applied tightly above a joint and allowing it to drop off. His reason for this was that if the limb were amputated in the ordinary way the patient might bear malice against his Surgeon, believing that it might have been saved. It was not till 1520 that the method of Celsus was definitely revived as the rule of practice by

Hans von Gersdorff, but as the cautery, or some more or less impotent styptic, was still the means employed to stop the bleeding, but little real progress was made. In the middle of the sixteenth century, about 1552, Ambroise Paré, the most celebrated Surgeon of his time, extended the use of the ligature to vessels wounded in amputations, arguing that, if the ligature were useful in accidental wounds and in varices, it was equally applicable to vessels divided in amputations. Amputation, as performed by Paré, was essentially the same operation as that described by Celsus, and although the arrest of bleeding was efficiently carried out by the ligature, the loss of blood during the operation was often considerable; for, though the "fillet" was bound tightly round the limb with the intention of diminishing the hæmorrhage, it seems never to have been applied with sufficient force completely to arrest the circulation. The instruments used for seizing the vessels were somewhat clumsy, and consequently the patient often lost so much blood before the ligatures were applied, that the majority of Surgeons continued for another century to prefer the cautery or some styptic. It was not until the beginning of the eighteenth century that the ligature really became the only recognised mode of arresting arterial bleeding. This result was brought about partly by the discovery of the circulation of the blood by Harvey in 1628, but chiefly by the invention of a really efficient tourniquet by Morel in 1674. Surgeons now were able to perform amputations without the fear of seeing their patient die of hæmorrhage during the operation, and from that time real improvement commenced.

In 1679, Lowdham, an English Surgeon, first suggested the plan of cutting a flap which could be made to cover the divided end of the bone, so as to obtain early union without necrosis and separation of the end of the bone. Thus there came to be two distinct modes of amputating a limb, the circular and the flap method, each of which underwent gradual development and improvement.

Amputation by the Circular Method.—The first improvement of the circular method of amputating, made after the invention of the tourniquet, was the introduction of what was known as the operation "*by the double incision.*" This mode of operating was introduced into practice almost simultaneously by Cheselden (1688—1751) of London, and J. L. Petit (1674—1750) of Paris. In this mode of operating, the skin and fat were divided by a circular incision; the assistant then, grasping the limb, pulled the integuments forcibly upwards, and the muscles were cut through to the bone by another circular sweep of the knife. The periosteum was then scraped from the bone with the back of the amputating knife for some distance upwards and the saw applied as high as possible. In the leg and forearm a smaller straight knife was used for cleaning the bones. This method did not aim at completely covering in the bone, but it provided such an amount of covering that it was possible for the stump to heal completely by granulation, usually after separation of the protruding end of the bone. The results were not so bad as might have been expected. The first Monro, who wrote in 1736, tells us that out of ninety-nine major amputations performed by himself and his colleagues in the Edinburgh Infirmary, only eight died, and none of these from the immediate effects of the operation. Monro secured the vessels by ligature, and dressed the raw surface of the stump with dry lint, which remained on till it was loosened by suppuration. A modification of the operation by the double

incision was introduced by the French Surgeon, Louis, in 1768. He noticed that, in making the circular incision through the muscles, the retraction of the superficial layers was greater than that of those near the bone. In order, therefore, to obtain a higher and more level division of the muscles, he divided the superficial layers with the skin and fat, and having drawn them forcibly upwards, cut the remaining muscle with a second sweep of the knife. A linen retractor was applied between the first and second incisions, and in order to allow the muscles to retract to the fullest possible extent, Louis was inclined to abandon the tourniquet and to trust to digital compression of the main arterial trunk. So far Surgeons had advanced little beyond the operation of Celsus; in fact, it is doubtful whether in amputation by the double incision, as performed at this time, the bone was better covered than in that by the Roman Surgeons, who raised the soft parts very freely before sawing. The first

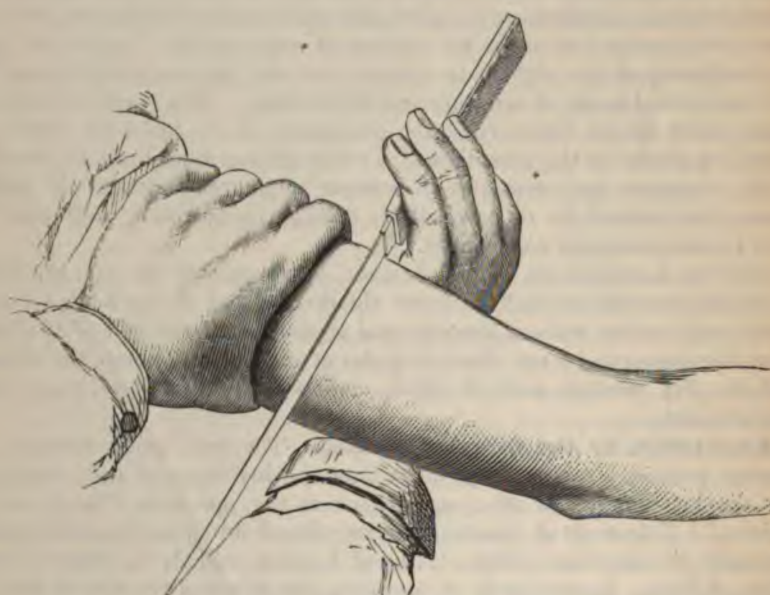

Fig. 21.—Amputation of Arm by the Circular Method. Commencement of first incision.

attempt to diminish the size of the raw surface left after amputation was made by Samuel Sharp about 1750. He passed two broad ribbon-like ligatures, each composed of eight well-waxed threads, through the edges of the wound about three-quarters of an inch from the margin of the skin, and drawing them tolerably tight, tied them in a bow-knot. It was soon found, however, that the tension thus caused produced such an amount of pain and fever that the plan was abandoned almost as soon as it was recommended.

Between 1770 and 1780 the great fact became recognised that the only way to obtain speedy healing of a stump is to provide sufficient covering to enable the edges of the skin to be brought together over the end of the bone, so as to meet easily without tension. This led to the invention of the mode of operating known as *amputation by the triple incision*, which was introduced into practice almost simultaneously by Benjamin Bell, of Edinburgh, William

Hey, of Leeds, and Alanson, of Liverpool. The two former performed the operation exactly as it is done in the present day by those who practise that method (Figs. 21 and 22). The skin and fat were first divided by a single sweep of the knife and dissected up for a distance equal to half the diameter of the limb; the muscles were then divided by another circular sweep of the knife and retracted for a distance varying from one to two inches, according to the thickness of the limb; and the bone was sawn as high up as possible. In the thigh and leg it was recommended by Hey to cut the posterior muscles longer than the anterior, to allow for their greater retraction. The edges of

Fig. 22.—Amputation of the Arm by the Circular Method. Sawing the Bone.

the skin were brought together in the transverse diameter of the limb, and a stump was formed with abundant covering for the bones, but necessarily with some puckering and projection at each angle.

The three incisions which gained for this operation the name of "the triple incision" were, first, the incision through the skin and fat; secondly, the incision through the muscles; and finally, the circular sweep round the bone to separate the muscles for retraction. The method adopted by Alanson produced much the same result, the only difference being that he attempted to divide the muscles in such a way as to leave a hollow cone with the bone at its apex, by turning the edge of the knife obliquely upwards. This proceeding was found by other Surgeons to be inconvenient, although in Alanson's hands it produced excellent results.

Amputation by the Flap Method was invented in this country by Lowdham, and was first described in a work by J. Yonge, with the extraordinary title of "Currus Triumphalis e Terebintho," published in 1679.

The operation was at first performed only in the leg, and the flap which was made from the calf was cut by dissection, and was composed chiefly of the integuments and subcutaneous tissues. In 1696, Verduin, of Amsterdam, independently invented a similar operation, but his method differed from that of Lowdham in the flap being cut by transfixion, instead of being raised by dissection. Both Lowdham and Verduin hoped to be able to arrest hæmorrhage by pressing the flap against the ends of the bones and securing it by bandages. The result was, that although in a few cases, especially in the hands of Yonge, who understood the necessity of drainage, union by first intention seems to have taken place, in the great majority the discharges were pent up and set up violent inflammation. In consequence of the unsatisfactory nature of the results obtained, the method was completely abandoned till 1739, when it was reintroduced by a French Surgeon named Ravaton, who modified the operation by making two rectangular flaps, one from each side of the limb, and securing the vessels by means of the ligature. A similar operation was performed by Vermale, of Mannheim, in 1767, in the lower part of the thigh. That the flap method still did not yield very favourable results, on account of the tendency to accumulation of discharges between the flaps in the absence of any proper system of drainage, is evident from the fact that in 1765, O'Halloran, "surgeon and man-midwife" at Limerick, who amputated by a single long flap, recommended that the flap and stump should be dressed as separate sores, and that they should not be brought together till the surfaces were covered by granulations. This plan did not, however, find much favour, and at the end of the last century Surgeons preferred the circular amputation in most cases, the flap operation being limited almost entirely to the upper part of the leg, the lower part of the thigh, and the distal parts of the foot. Alanson and Hey, whose names have already been mentioned in connection with the circular method of amputation, practised and improved the flap operation in those situations. During the first fifty years of this century, however, the flap operation came greatly into favour in this country, and was during the latter part of that time supported by the able advocacy of Liston, who invariably amputated by that method, and who certainly did it with wonderful rapidity and precision.

Amputation by the double flap, as it is still practised, is thus performed (Fig. 23). The two flaps may be made either by dissection, cutting from without inwards; or by transfixion, cutting from within outwards. Transfixion is adapted only to fleshy parts, as the thigh or arm; but cutting from without inwards will be found to afford the best result, and is indeed the only mode of forming the flap in some situations in which the bones are naturally thinly covered, as on the dorsal aspect of the fore-arm, the anterior part of the leg, or just above the ankle-joint, or where the soft parts have been wasted by chronic disease. The flaps in transfixion should be made by a steady sweeping cut, so that the soft parts may be evenly and smoothly divided. Their length must, of course, be proportioned to the thickness of the limb. If they be cut too long, too much muscle will be left on the stump, and the flap itself is usually badly fashioned and pointed. Should the Surgeon feel that he has made this mistake, the wiser plan will be at once to round off the ends of the flaps. Should they have been cut too short, the soft parts must be forcibly retracted, and the bone cleared by circular sweeps of the knife, and sawn as high up as possible.

The flap farthest from the great vessels, as that on the outer side of the thigh or arm, should be cut first. In making the inner flap, great care must be taken to wind the point of the knife well round the bone, so as not to transfix and split the vessels, but to cut them as long as possible. As a general rule, the less loose muscle that is left on the stump, the better ; hence, where there is an

Fig. 23.—Amputation of the Thigh. Antero-posterior Flap Operation. Flaps cut by Transfixion.

equal thickness of soft parts round the bone, as in the arm and thigh, the flaps should be cut short, well retracted, and the bone cleared by circular sweeps of the knife as high as necessary. The bone thus lies at the bottom of a deep hollow beyond the angle of junction of the flaps, and there is less chance of a conical stump being left.

In cutting a flap from without inwards, it is of the greatest importance to remember that the edge of the knife must never be turned towards the under surface of the flap, but always towards the parts to be removed. After marking out the flap with the point of the knife, the Surgeon takes the edge of the skin between the finger and thumb of his left hand and raises it from the parts beneath. The portion of the flap which is thus raised is therefore at right angles to the surface of the limb, and the knife must also be kept in a similar direction, or its edge will be turned towards the base of the flap, and by scoring its under surface will greatly increase the danger of sloughing. The flap must be raised evenly across the limb, and one side must not be allowed to get in advance of the other. When bands of areolar tissue are seen passing from the flap to the parts beneath, the operator must divide these at the end that is attached to the parts to be removed. There should be no hurry about raising the flap by dissection, as under the influence of anæsthetics

the lengthening of the operation by two or three minutes is a matter of but little importance. It is better to spend one or two minutes more over the operation, than to have to re-amputate on account of sloughing of the flaps.

The simple circular and the double-flap operations being thus brought to perfection marks the limit of the improvement in amputation which resulted from the invention of the tourniquet; and before the invention of anæsthetics Surgeons were divided in opinion as to which of the two methods was to be preferred when the nature of the case allowed of a choice. The advocates of the flap operation claimed for it the following advantages: that it was easy of performance, and could be carried out with great rapidity, thus saving pain to the patient; that the thick muscular cushion left over the end of the bone made a better covering and rendered protrusion of the bone less likely to occur; and that the accuracy of fit obtained by this method favoured union of the wound by first intention. The advocates of the circular method maintained that the light covering formed by the skin and fat was less likely to be displaced by the involuntary movements of the muscles, and was quite as capable of uniting by first intention as fleshy flaps; and that protrusion of the bone was not dependent on the method adopted, but upon insufficiency of covering. As long ago as 1783 it had been pointed out by Mynors that the muscular cushion is more an ideal than a real advantage; for in course of time the muscular tissue in the flap becomes atrophied and absorbed, until after a few months the difference in covering between a stump formed by the flap method and one by the circular is inappreciable. The advocates of the circular method also maintained that the vessels being cut transversely retract more perfectly, and are less likely to bleed afterwards, and that the wound resulting from the operation is smaller than that produced by the flap method. The great objection to the circular operation was undoubtedly its tediousness and painfulness, and consequently the flap operation became decidedly the favourite with most Surgeons. The invention of anæsthetics, however, left the Surgeon free to consider solely what method of amputation furnishes the best results. Hence many plans of operation that were almost discarded thirty years ago have regained their ascendency, and flaps are now most frequently carved out by cutting from without inwards, regardless of the greater length of time required, provided the result is more satisfactory.

As a result of the thought and labour devoted to the improvement of amputation since the invention of anæsthetics, certain general principles have come to be universally recognised as guiding the Surgeon in the performance of the operation. These may be briefly stated thus:—

1. The covering must be sufficient to meet over the bone without the slightest tension;

2. The amputation should be so performed that the scar, when the stump is healed, shall not lie over the end of the bone;

3. If possible, a dependent opening should be provided for the exit of the discharges;

4. These advantages must be obtained with the smallest possible sacrifice of the healthy parts of the limb.

Each of these requires consideration more in detail.

1. To PROVIDE A SUFFICIENT COVERING.—It was long ago pointed out by Mynors that the standard by which we must estimate the amount of covering required is the diameter of the limb at right angles to the line in which the

cicatrix is to be placed, and taken at the point at which the bone is to be divided. In operating on the dead body, it is evident that if two equal flaps, each half the diameter of the limb, were cut, measuring from the point at which the bone is sawn to the end of the flaps, they would accurately meet and cover in the bone, but such flaps in the living body would be totally inadequate on account of the shrinking from the elasticity of the skin and the displacement from the contraction of the muscles. Consequently, it is necessary to provide another half diameter of covering *at least*, and in some situations even this amount is insufficient. As an illustration of the above rule, let us suppose a limb is to be amputated, the antero-posterior diameter of which, at the point where the bone is to be sawn, is six inches, the necessary diameter and a half of covering could be obtained in the following ways amongst others;—1. One long flap nine inches long; 2, two flaps, one six inches long and the other three; 3, two equal flaps four and a half inches long; 4, two equal flaps three inches long, and retraction of the muscles from the bone to such an extent as to provide an inch and a half of covering on each side; 5, a circular incision raising the skin and fat for three inches, and another circular cut through the muscles with retraction of the soft parts from the bone for one inch and a half.

The general rule that one diameter and a half is sufficient, requires modification under various conditions of the tissues of which the covering is made, and in various situations. In very old people the skin has frequently lost much of its elasticity, but it is not wise to shorten the covering on this account, as the tissues being feeble are less capable of withstanding the irritating effect of tension. In amputation through chronically inflamed tissues, the retraction is also reduced to a minimum on account of the rigidity of the parts; but here again it is unwise to shorten the covering; in fact it is better to make it a little longer, as the flaps are very apt gradually to shrink during or after the healing of the stump. In limbs in which the muscles have undergone extreme fatty degeneration, the retraction caused by their tonic contraction is absent, so that the minimum covering of a diameter and a half is amply sufficient. In the lower third of the thigh the covering should always be increased to two diameters to allow for the very excessive retraction of the long flexor muscles of the leg. In amputation of the leg by the long calf-flap, it is also necessary to provide very abundant covering to allow for the subsequent shrinking of the muscular tissue which forms the posterior flap.

2. That the scar shall not be over the end of the bone.—It is evident in the first place that protrusion of the bone is more likely to occur if the two flaps in a flap amputation meet exactly over its end; but the chief object in placing the scar so that it shall be free from the bone is to avoid a painful stump. If the scar in the skin is adherent to the bone it becomes extremely liable to ulceration from slight injuries. If the scar be placed well away from the bone, it is often possible in amputations of the lower limb for the patient to bear a certain proportion of his weight on the end of the stump, which gives greatly increased steadiness in walking on an artificial limb.

3. That a dependent opening is to be provided for the exit of discharge.—This may be stated in other words thus: that the covering of the stump shall be taken chiefly from the dorsal surface of the forearm, and from the anterior part of the limb elsewhere. Perfect drainage is essential for union of any wound by first intention, and consequently it is needless to

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3. THAT A DEPENDENT OPENING IS TO BE PROVIDED FOR THE EXIT OF DISCHARGE.—This may be stated in other words thus: that the covering of the stump shall be taken chiefly from the dorsal surface of the forearm, and from the anterior part of the limb elsewhere. Perfect drainage is essential for union of any wound by first intention, and consequently it is needless to

point out the importance of so arranging the covering that the force of gravity shall aid, and not oppose, the escape of discharges. In exceptional cases, as in some of the amputations in the foot, the advantages of the flap taken from the heel or sole in providing a covering upon which the patient can bear his whole weight are sufficient to counterbalance the difficulty of drainage that sometimes is met with in these operations. If the covering be taken chiefly from the front of the limb, it is evident that not only will gravity aid in draining the wound, but also that it will tend to keep the longer flap in its position. If the covering be taken chiefly from behind, as in the transfixion-amputation in the leg, the tendency of the heavy muscular flap to fall backwards can be counteracted only by fixing it to the anterior by sutures or strapping ; tension of the short flap is produced and it may slough over the bone ; any insufficiency in external support allows the posterior flap to fall away, fluids bag in the gap, and speedy union is impossible.

4. That these advantages are to be gained with the smallest possible sacrifice of the length of the limb.—Experience has shown conclusively that the danger of an amputation increases as the point at which the bone is sawn approachesthe trunk. It is evident that the bone can be sawn at the lowest possible point if the covering is taken equally from the two sides. To take as an example a limb the antero-posterior diameter of which is six inches, and which consequently requires nine inches at least of covering to form a good stump, and supposing the nature of the case makes it impossible to obtain covering from a point lower than the end of the bone to be sawn through, if it is to be taken equally from the two sides, the bone would be sawn four-and-a-half inches above its lower end ; if from one side only, nine inches. If, however, the anterior flap was five-and-a-half inches long and the posterior three-and-a-half, the advantages of a dependent opening and a scar removed from pressure could be obtained with the sacrifice of only one inch more bone than if the flaps had been of equal length. The Surgeon will therefore adhere to the rule of taking the covering as equally as possible from the two sides of the limb only as far as is consistent with the other essentials of a good amputation, a dependent opening for drainage, and a scar away from the bone. A longer stump is more easily fitted with an artificial limb and gives the patient greater control over it.

These essential features of a good amputation being agreed upon, the questions of the best material of which to form the covering, and the best way of raising it, remain to be considered.

All Surgeons are now agreed that too much muscle in a flap is an unmitigated evil. The objections to muscular flaps are, that they are heavy, and consequently liable to be easily displaced ; that, supposing any voluntary movement or involuntary jerking or twitching of the limb to occur, the surfaces of the flaps are moved upon each other, and primary union is thus prevented, and that this is especially likely to happen if the sharp edge of the sawn bone is in direct contact with a muscular flap bent over its end ; that muscular flaps retract to a considerable extent after the operation, and continue to shrink for some time, thus causing a greater tendency to protrusion of the bone ; and lastly, that as in the end the muscle completely wastes away, the idea that a muscular flap forms a better cushion than one composed only of the skin and subcutaneous fat is erroneous. None of these objections can be raised to a covering composed solely of the cutaneous and subcutaneous tissues, but, on

the other hand, in very emaciated subjects, such a covering is very thin, and is apt to suffer from the direct pressure of the bone against it, and consequently in such cases it is well to protect it by raising a certain amount of muscle with it. Skin flaps also, if very long, are apt to slough, as their vascular supply is somewhat limited, and this accident is especially liable to happen in old people. In any patient, whether young or old, fat or thin, sloughing will almost certainly occur if the Surgeon turns the edge of the knife towards the flap instead of keeping it directed to the parts to be removed. Common sense would suggest also that it is wise to thicken the base of a flap with a little muscle when possible, if circumstances require it to be made of more than ordinary length. If the covering in most parts were made solely of skin and fat, the retraction of the muscles would leave the bone protruding sharply beneath the flaps, and the object of the Surgeon is therefore to save so much muscle that after full retraction has taken place it shall still be level with the sawn end of the bone. In order to obtain this result, the proportions usually sufficient are to provide one diameter of covering composed of the skin and subcutaneous structures, and half a diameter of muscle, or more if the retraction is expected to be considerable, as in the lower part of the thigh. In all cases the operator should bear the principles in mind, and be guided in his performance by circumstances, considering the age and state of health of the patient, the amount of subcutaneous fat, the length of the flaps, and the situation of the amputation, and suiting the relative proportions of skin and muscular covering to the nature of the case. A mere mechanical amputator can never be a good one.

In amputating for diseased joints, it often becomes a question whether the structures covering the articulation are in a fit state to be used in the formation of flaps. As a general rule, it may be stated that the chronically inflamed tissues covering a diseased joint, even when perforated here and there by sinuses, form excellent flaps; but it must be borne in mind that their vitality being somewhat lower than natural, they must be carefully handled to avoid unnecessary bruising, and that they are liable to shrink considerably as the stump heals, and consequently their length must be slightly greater than if the tissues were healthy. In tuberculous disease of joints any pulpy granulation tissue which may be left in the flap should be carefully dissected away, and sinuses scraped with a sharp spoon, and disinfected with some powerful antiseptic. Such flaps yield a large amount of serous exudation during the first few hours after the operation, and ample drainage must be provided for this.

In some of the modern methods of amputating about to be described it has been the object of the Surgeon to combine as far as possible the advantages of the circular and flap methods in one—following the rules just laid down as to the essentials of a good amputation.

Amputation by the Modified Circular Method.—In 1839, Liston proposed a combination of the double flap and circular operations, which greatly improved the shape of the stump of the circular method, and somewhat increased the ease of the operation (Fig. 24). Two semilunar incisions, with their convexities downwards, are made through the skin from side to side of the limb; the flaps, which are each about one quarter of the diameter of the limb in length, are then dissected up and the skin and fat raised circularly above the angle of union for a distance equal to the length of the flaps, thus exposing the muscles half a diameter above the extremities of the flaps. The

operation is then completed by division and retraction of the muscles as in the ordinary circular method. This operation is especially indicated in muscular parts, such as the arm, thigh, or leg. The advantage of this procedure over the ordinary flap-operation is very great in stout muscular subjects.

Fig. 24.—Modified Circular Amputation in the upper third of the Leg.

Amputation by a long and a short rectangular flap. Teale's Method.—The late Mr. Teale of Leeds, in 1853, invented a method of amputating by a long and a short rectangular flap. In selecting the structures for the formation of the long flap "such parts must be taken as do not contain the larger bloodvessels and nerves." In the lower part of the thigh and in the leg the long flap will therefore be anterior and the short posterior ; in the fore-arm the long is dorsal and the short palmar, and in the arm the long flap will be chiefly taken from the outer side.

The long flap is a perfect square, and the rule for its formation is, that its length and breadth must each be equal to half the circumference of the limb at the place of amputation (Fig. 25). If the circumference be 12 inches, the length and breadth of the flap, both at its base and at its free extremity, should be 6. The short flap is to be one-quarter the length of the anterior flap ; in the case above supposed it would be $1\frac{1}{2}$ inches. In performing the operation the measurements must be carefully made, and the outline of the flaps marked on the limb with ink. Both flaps are to be made to include all the soft parts of the limb. The bones are sawn in the angle of union of the flaps, without any previous retraction of the soft parts. After the vessels have been secured, the long flap is folded over the end of the bone, and attached by suture, partly to the short flap, and partly to itself ; thus the proximal quarter of the long flap is first accurately sewn to the short flap ; the remaining part of the long flap is then doubled over on itself, its free end being accurately fitted to the free end of the short flap, and attached by sutures ; finally stitches are applied where the terminal part of the flap is in contact with the second quarter, as in the figure (Fig. 26). The advantages claimed by Teale for his method of amputating were, that it provides an abundant covering free from tension. This it evidently does, as the covering amounts to $1\frac{1}{2}$ diameters of the limb. Secondly, it provides a dependent opening for the exit of discharge ; and thirdly, that when it is healed the cicatrix is behind the bones, and that consequently the patient can bear the whole or a part of his weight on the end of the stump ; this is especially advantageous after amputation in the thigh or leg, where a stump capable of bearing direct pressure would be of very

essential service to the patient. Teale advised, however, that the whole pressure be not borne on the end of the bone, but that it be reduced to one-half by an elastic pad composed of numerous layers of flannel beneath the end of the stump, the remainder of the weight being distributed in the usual way on the upper part of the limb: thus not only relieving the stump, but securing greater steadiness of gait. In the upper extremity, however, no direct pressure is made upon the end of the stump in the adaptation of artificial limbs; hence, the rectangular appears in these situations to possess no advantage over the other double-flap methods, so far as the utility of the stump is concerned.

But, whilst fully admitting the advantage possessed by the rectangular method in the formation of a well-covered stump, especially in the lower extremity, we must not close our eyes to certain disadvantages which appear to me to be inseparable from it. One disadvantage consists in the necessity of sawing the bone at a higher point when one flap is made of such extreme

Fig. 25.—Lines of Incision in Teale's Amputation.

Fig. 26.—Teale's Amputation: Stump.

length than when two shorter ones more nearly equal are fashioned. Thus, for instance, in an amputation of the thigh for injury about the knee-joint, the long rectangular flap in an adult would require to be about 8 inches in length, and the femur must consequently be sawn at least as far as this above the patella: whereas, in the ordinary double-flap amputation, two shorter flaps, each about 4 inches in length, will be found sufficient to cover in the bone, which may consequently be sawn at a proportionately lower point. Thus the rectangular method contravenes the principle in amputation, not to remove the limb at a higher point than is absolutely necessary, the danger to life increasing with every inch that is removed. In amputations for malignant disease, also, the long flap, which has to be cut close to the morbid growth, would run a greater risk of infiltration than two shorter ones taken higher up in the limb: the bone in both cases being sawn at the same level.

Should union by the first intention fail and suppuration ensue, in the rectangular amputation the thick fleshy mass which enters into the formation of the long flap becomes a source of great inconvenience, bulging out from under the skin, and requiring considerable management in the after-treatment.

For these reasons the unmodified form of Teale's amputation is hardly to be recommended.

Amputation by the long Anterior Flap.—At the time that Teale was recommending the long rectangular flap in all parts of the body, Carden, of Worcester, was advocating the employment of a long anterior flap in a form of amputation invented by him for removal of the thigh immediately above the knee. In his operation, which will be described amongst the special amputations, a single long anterior flap was made, the extremity of which was rounded in form.

Spence of Edinburgh, who fully recognised the advantages of Teale's

method of amputation in the lower third of the thigh, suggested a modification by which he hoped to obtain them with less trouble and without producing so large a wound. He made no posterior flap, but compensated for it by retracting the soft parts from the bones to an extent equal to its length. The anterior flap was to be made a little longer than the diameter of the limb; and its angles being rounded, it was allowed simply to hang over the end of the stump, without being folded upon itself as in Teale's operation. The posterior parts were divided from without inwards by a single sweep of the knife. By this method, however, the bone was sawn as high as in Teale's method, so that the gain was not very great.

In 1860 Lister pointed out that the advantages of Teale's method could be obtained with considerably less sacrifice of length in the limb by taking the covering more equally from the anterior and posterior aspects. A dependent opening for the exit of the discharges, and a scar placed behind the bones may be obtained in almost all situations by making an anterior flap two-thirds of the diameter of the limb in length, and a posterior half that length, as the bone is in almost all parts situated more towards the anterior than the posterior aspect of the limb. In all parts of the limbs the flexors, being the muscles with the longer bellies, retract more extensively than the extensors; and, consequently, if, when the operation is finished, the line of union of the flaps is on the flexor aspect of the bones, it is quite certain that the scar, when the stump is healed, will be in a similar position. The method of operating, therefore, recommended by Lister as best suited to the amputations of the forearm, leg, and thigh, is the following. An anterior rounded flap, equal in length to two-thirds of the antero-posterior diameter of the limb at the point at which the bone is to be sawn, is raised by dissection. In the lower thirds of the leg and forearm the bones form so large a proportion of the limb that, in order to make sure that the scar shall be placed behind them, it is necessary to make the length of the anterior flap equal to the diameter of the limb. In raising the anterior flap the operator will, if he think fit, try to take up some muscle at its base to thicken it and so ensure its vitality. This is to be recommended for all parts in thin or feeble subjects, and in the thigh in every patient. The flap is not, however, under any circumstances to be too fleshy and heavy. A posterior skin-flap, half the length of the anterior, is next raised. The muscles are then divided circularly and retracted from the bone for a distance equal to at least one quarter of the diameter of the limb; in the thigh it is better always to retract for half a diameter. It is evident that in the leg this retraction may be rather difficult, especially in secondary amputations in which the tissues are swollen and infiltrated; but the difficulty is easily overcome by extending the incision upwards from the angle of the flaps, either on one or both sides of the limb, to the point at which the bones are to be sawn. This mode of amputating combines the advantages of both the circular and the flap operations: it has the light covering and absence of excessive muscle of the circular, with the accurate fit, the good drainage, and the well-placed scar of the flap method. It is in fact a combination of the flap and circular operations, and therefore sometimes is spoken of as the "combination method."

Amputation by the Oval Method, which is especially adapted to removal of fingers or toes and disarticulations at the shoulder and hip, is essentially a circular amputation with a longitudinal incision made up one side of the limb.

to facilitate the retraction of the soft parts and the exposure of the joint at which disarticulation is to be performed. The oval form is given by rounding off the angles formed by the junction of the longitudinal with the circular incision. When the longitudinal incision is continued for some distance above the commencement of the true oval part, the operation is frequently spoken of as amputation by the "racket-shaped incision."

Sawing the Bone.—In all methods of amputating, as soon as the incisions have been made through the soft parts, the bones must be cleared for the application of the saw. While doing this the soft parts must be firmly retracted by the assistant or by the Surgeon himself, if he stands so as to take his own flaps. For the purpose of retraction the hands are usually sufficient, though some Surgeons still use retractors made of pieces of stout calico or linen. The retractor must be about 2 inches wider than the diameter of the limb and about 3 feet long. If there is only one bone, one end must be torn into two tails. The retractor is soaked in an antiseptic lotion, and the two tails of the divided end are then passed one on each side of the bone and slightly crossed on each other. The assistant then, taking the two tails in one hand and the undivided end in the other, pulls them forcibly upwards. If there are two bones, the divided end must be torn into three tails, the middle one of which is passed between the bones. Retractors are of use only in circular or combined flap and circular amputations. In the pure flap operations they are unnecessary for retraction of the soft parts, but they are still of use in protecting the muscles from the teeth of the saw and in keeping the surfaces free from the bone-dust: for the laceration of the deep muscles by the saw and the imbedding of bone-dust in their substance may interfere seriously with union. If a retractor be used, the final clearing of the bone is completed after it has been applied.

The older Surgeons cleaned the bone by scraping the periosteum up with the back of the knife. Most modern operators content themselves with stripping the muscles from the bone as high as may be necessary, and finally dividing the periosteum at the point at which the bone is to be sawn by a firm circular sweep of the knife from heel to point, first round the under surface of the bone, and then round the upper surface in the opposite direction. If there be two bones, care must be taken in clearing them in this way not to direct the edge of the knife upwards in the interosseous space higher than the line to which the saw is to be applied, lest any artery be cut where, on account of its retraction, it will be difficult to secure. Those, however, who are willing to sacrifice a little elegance and rapidity will find an undoubted advantage in carefully raising the periosteum with the muscles in retracting the soft parts. This is easily done by a periosteal elevator, so as to leave a tube of periosteum which will cover the end of the bone when the stump is closed, or may be previously brought over the end of the bone and secured in that position by a few catgut stitches. The advantages gained by thus saving the periosteum are not very evident if all goes well and the stump heals by first intention, but should suppuration occur and the bone protrude, it will be found that the end is completely covered by the periosteum, which becomes firmly adherent to it after four or five days. The medullary canal being in this way closed, the danger of septic osteomyelitis, necrosis and pyæmia, is greatly diminished. In cases healing without suppuration a rounded end to the bone seems to be formed at an earlier period than when the periosteum is not saved, and in the

forearm it prevents the union of the divided ends of the bones and ensures a considerable degree of pronation and supination in the stump.

The bone having been properly cleared and the soft parts firmly retracted, the saw is applied to the highest point exposed. In order to saw the bone quickly and steadily, the first cut should be made so as to form a deep groove to receive the teeth: to do this, the heel of the saw is steadied against the left thumb, which is pressed on the bone, and the whole length of the instrument is sharply drawn across the bone. The groove thus formed receives the edge of the saw: and the bone may then be quickly cut through by long, light, and sweeping movements of the instrument. The assistant must carefully support the part to be removed; neither depressing it so as to snap the bone as it is weakened by sawing; nor raising it so as to lock the saw. In sawing a single bone the position of the saw is gradually changed from the horizontal to the vertical, the bone being then less likely to break if the limb be improperly supported. When there are two bones of equal strength in the limb, as in the forearm, they should be cut through at the same time; but in the leg, the fibula, being the weaker, should always be first divided. Should the division be made irregularly, and splinters of bone project, these must be snipped off with cutting-pliers.

In performing an amputation, the preparations directed on page 40 must be accurately carried out. The Surgeon must see that the **Amputating Instruments** are in proper order, and of good construction. For the smaller amputations straight bistouries, narrow or broad in the blade according to the size of the part to be removed, will be required. Scalpels, also, not too broad in the blade, are useful in cases in which the bistoury, from its length, might be inconvenient. Cutting-pliers, with long, strong handles and short blades, either straight or curved, are especially required in amputations about the hands and feet. The knives for the larger amputations should have smooth ebony or steel handles, and be well balanced. The back of the blade should run straight to the point, and be well rounded. The edge should taper off towards the point, with a good convexity. The breadth of the blade should be from three-fifths to two-thirds of an inch, and its length should be proportioned to the size of the limb to be removed. In operating by transfixion in order to make a good sweeping cut, so as to form a well-rounded and smooth flap, the blade should as a general rule be about equal in length to double the diameter of the limb. For raising the flaps by dissection many Surgeons prefer shorter knives. The saw should be strong in the blade and back so as not to bend in cutting. The blade must be of good breadth, and its teeth must be well set, so that it shall not hang as it works its way through the bone. Artery-forceps of the ordinary bull-dog kind, and torsion-forceps will be required; and some dozen or more of forcipressure-forceps should always be ready for the temporary arrest of hæmorrhage from the smaller vessels while the larger are being secured.

The Arrest of Hæmorrhage.—After the limb has been removed the first thing to be done is to restrain arterial hæmorrhage. The vessels are to be secured by some of the means described in Chapter XIV. The means most commonly adopted in the present day are torsion and ligature with prepared catgut or fine silk, which may be left in the wound without fear of after-trouble. Whatever means of arresting hæmorrhage are adopted, all vessels visible on the surface of the flaps should be secured before the tourniquet is removed, the

Surgeon being guided by his anatomical knowledge to the situation of the more important branches. In addition to the main trunk, from two to four or six smaller vessels usually require to be secured : but sometimes, either from the existence of malignant disease, or of extensive suppuration in the limb, the stump is excessively vascular, and a very large number of ligatures may be required. I have, in these circumstances, more than once had occasion to apply between twenty and thirty ligatures to vessels in the arm and thigh.

Free arterial bleeding will sometimes take place from a point in the cut surface of the bone, in consequence of the division of the trunk of the nutrient artery. This hæmorrhage is best arrested by pressing into the canal one or two strands of carbolised catgut twisted together ; or, if this fail, it may be plugged with a small piece of carbolised sponge, which will become buried in the stump and absorbed almost as easily as the catgut. The old plan of inserting a wooden plug with a wire to it should never be resorted to if other means are available, as it is certain to serve as a centre of suppuration, and it causes disturbance of the wound when it is removed.

It is impossible to take too great care in arresting not only all arterial hæmorrhage, but all oozing of blood before closing the wound. It is to painstaking arrest of every trace of bleeding that the great success of some Surgeons in obtaining primary union is in part to be attributed. To have to open up the wound to secure a bleeding vessel within an hour of the operation is one of the most annoying accidents that can happen to a Surgeon, and is most damaging to the prospect of speedy union of the wound, but even this is less injurious than the distension of the flaps with a coagulum, the result of oozing which, perhaps, stops just short of obliging the Surgeon to open up the wound for its arrest.

Before closing the wound, the large nerves should be drawn out and cut short with scissors to prevent their becoming implicated in the superficial scar. Any projecting tendons should be cut short in the same way.

Closure of the Wound.—The hæmorrhage having been arrested, the covering is brought together over the bone by means of sutures. In a well-made stump the covering is so loose that no force is necessary to bring the edges together ; consequently, adhesive plaster can never be required. In cases in which a strictly antiseptic dressing is being used, unwaxed silk boiled for half an hour, and then soaked for twenty-four hours in a 1 in 20 solution of carbolic acid, makes the best sutures. If the dressing is such that decomposition of the discharges is possible, it is better to use silkworm gut, horsehair, or metallic sutures, as they do not absorb the septic matter, and are consequently quite unirritating if they are not tight. In inserting the stitches, it is better to put in two or three thick sutures, either of silk or wire, at intervals of about one inch to one inch and a half (Fig. 27). They should get a good hold of the skin and fat for at least one inch from the edge of the wound. These bear any strain that may arise from swelling or retraction. Between them finer sutures must be inserted, at intervals of about half an inch, bringing the skin edges into accurate apposition. Such close sewing as this, however, would somewhat endanger primary union, unless a proper exit for the discharges were provided for by drainage tubes. These are best made of india-rubber. One may be inserted in each angle of the wound, and, if it seems necessary from the size of the stump, a third may be placed in the middle. Drainage-tubes must be cut level with the surface of the wound, and above all it must

not be forgotten to fit each with a couple of threads, one on each side of its orifice, to prevent its slipping into the wound and being lost there, an accident which has frequently happened from neglecting this precaution.

Dressing the Stump.—An amputation leaves an incised wound which must be treated on those principles which are fully described in Chapter IX. These may be briefly summed up thus :—1. Complete arrest of hæmorrhage ; 2. Removal of all coagulum, bone-detritus, or other foreign bodies ; 3. Close and accurate coaptation of the surfaces of the wound ; 4. Efficient drainage ; 5. Perfect rest of the part ; 6. Asepticity of the wound. These objects may be attained by many modes of treatment, but perhaps by none more perfectly than by the absorbent antiseptic wool or gauze dressings now so commonly used. These by their uniform elastic pressure, support the stump, keep the surfaces of the wound in accurate apposition, and greatly diminish the exudation during the first twenty-four hours. They require changing infrequently, and in many cases the first dressing may be left on till the stump is practically

Fig. 27.—A Stump showing the mode of applying Suture and drainage-tube. A drainage-tube.

healed. In this way more perfect rest is given to the wound than by any other method of treatment. Some Surgeons, trusting to the elastic pressure of the dressing to diminish the exudation and to prevent its accumulation in the wound by maintaining perfect apposition of the surfaces, have given up the use of drainage tubes in all amputations through healthy tissues. It is, however, wiser, as a rule, to insert one or two short tubes which may be removed, if all goes well, at the first dressing. They give a greater certainty that no fluid shall accumulate between the flaps, and do not practically retard the healing of the wound. The necessity for drainage is greater if the wound be washed with a strong solution of carbolic acid before being closed, as this antiseptic seems considerably to increase the early serous exudation. The solutions of perchloride of mercury do this to a lesser degree. The details of the application of these and other antiseptic dressings will be found in the chapter on the treatment of wounds.

It must often happen, however, that the Surgeon is obliged to amputate through tissues which are already inflamed, or that he may not have at his command the materials necessary for the more perfect forms of antiseptic dressing. Under these circumstances it is essential that a proper provision be made for the escape of the discharges either by the use of drainage-tubes if they are at hand, or if they are not, by leaving a sufficient space between the

stitches and arranging the dressing in pads, so as to have the edges of the wound free. In the hands of some Surgeons the open treatment, that is to say, arranging the stump on a pillow without the application of any dressing has proved very successful. The late Mr. Callender obtained excellent results by the use of drainage-tubes for from twenty-four to thirty-six hours, and placing the stump on a well-padded splint, to which it was bandaged, so as to prevent all voluntary movement and disturbance from involuntary twitchings. The wound was dressed with lint soaked in carbolic acid and oil, and cleansed when necessary with a glass brush dipped in a spirituous solution of carbolic acid. In fact any method of treatment which secures the essential conditions of rest, drainage and asepticity will, if carefully carried out, be followed by success. The amount of rest that a stump gets depends to some extent upon the skill with which it is handled by the Surgeon at the dressing, but it is evident that the most perfect rest will be obtained by those methods of treatment which involve the least frequent change of dressing. Whatever dressing may be adopted, the stump must be supported on a soft pillow, and the weight of the bed-clothes taken off by a cradle; or should the covering be composed of heavy muscular flaps, it may advantageously be placed on a well-padded wire splint.

In some cases, although the flaps may appear abundant at the time of the operation, the retraction may much exceed that which was anticipated, and a wide granulating surface may be left after the deep parts have healed. This is most common in amputations in the thigh. If the covering has really been sufficient, this will usually remedy itself, the contraction of the granulating sore gradually bringing the skin edges together. The healing of the stump under these conditions is hastened by applying weight extension, which is done thus: a piece of diachylon plaster is cut of sufficient length to reach to the next joint above the amputation on the anterior and posterior aspects of the limb, and to form a loop extending at least one foot beyond the end of the stump. Its width at each end must be nearly half the circumference of the limb, but in the middle it may be somewhat narrower. The plaster is well warmed and applied to the stump, and surrounded by a few turns of a bandage made of the best elastic Welsh flannel. A wide "spreader," made of a piece of wood with a hole in it for the rope which supports the weight to pass through, is then put into the projecting loop of plaster. The spreader saves the end of the stump from being squeezed. The weight is then applied over a pulley in the same way as is described under the treatment of fracture of the femur. The results of this treatment are most satisfactory, especially in the lower third of the thigh.

In most cases the stump is benefited by the application of a bandage to support and mould it during the final stage of healing. After cicatrisation is completed, the patient may go about on crutches, but must not wear an artificial limb for some months, until the parts have become firmly consolidated; during the whole of this time the stump should be kept carefully bandaged, and not exposed to injury.

Simultaneous or Rapidly Consecutive Amputation of two Limbs for severe injury or for gangrene, has occasionally been successfully practised, either by two Surgeons performing the two amputations at the same time; or by the same Surgeon doing first one and then the other, the vessels of the first limb being secured by an assistant whilst the second limb is being removed. The circulation through both lower extremities may be completely arrested by

compressing the aorta with Pancoast's tourniquet. By means of this valuable instrument, I have amputated both thighs in close succession without waiting for the ligature of the arteries in that which was first removed. The object in two simultaneous amputations is to lessen the shock by throwing, as it were, that of the two operations into one. In doing this, however, the Surgeon must necessarily be guided by the circumstances of the case, for if the patient be very greatly depressed, the infliction of so severe an injury may extinguish life at once. Under such circumstances it is perhaps better to let the patient die in peace than to hasten his death by a hopeless operation.

STUMPS.

On examining the structure of a stump after one or two years have elapsed from the time of its formation, it will be found to be composed of a mass of fibrous and areolar tissue, any muscular substance which may have entered into its formation having completely disappeared. Any tendons which may have been divided will be either lost in the fibrous tissue of the scar, or will have formed new attachments to the bones. The end of the bone is rounded and the medullary canal closed by a layer of compact bone. The bone itself is often atrophied, its compact tissue being thinner, and its cancellous tissue more spongy than in the corresponding part on the other side. The vessels are obliterated as high as the nearest branch and converted into fibrous cords. The ends of the nerves are bulbous (Fig. 28), the bulbs being composed of fibrous tissue, among which are great numbers of new nerve fibres twisted and rolled upon each other in all directions.

Fig. 28.—Endings of Nerves in a stump.

The proper adaptation of **Artificial Limbs** is a matter of considerable consequence; and the ingenious mechanical contrivances that are at the present day applied to stumps, leave little to be desired. The Surgeon had better leave the details of these mechanical contrivances to the instrument-maker; but he should see that they are made light, consistently with sufficient strength and support, and that the end of the stump is never injuriously pressed upon by them. Thus, after amputation of the thigh, the artificial limb should take its chief bearing point from the lower part of the pelvis and hip. In amputation immediately below the knee, this joint should be bent and received into the socket of the instrument; and, if the amputation be at a lower point than this, and the stump be extended into the artificial limb, its end must be protected from injurious pressure.

In all amputations of the lower limb in which the Surgeon has succeeded in producing a satisfactory loose covering, not adherent to the bone, and with the scar well behind it, the patient should be encouraged to bear part of his weight, at least, directly on the end of the stump. Not only does this give increased steadiness in walking, but it is said to diminish the tendency to excessive atrophy of the soft parts which sometimes occurs in old stumps. The plan recommended by Teale of gradually accustoming the end of the stump to bear pressure will be found most satisfactory. The patient must prepare a number of circular pieces of flannel of the same diameter as the socket of the artificial limb. He first puts in a sufficient number of these to form a pad

just touching the stump; after this he adds one daily till the stump becomes accustomed to bear the necessary degree of pressure. In all amputations through the knee-joint or condyles of the femur, and in Syme's or Pirogoff's amputation at the ankle, the patient should be able to bear his whole weight on the stump without difficulty.

MORBID CONDITIONS OF STUMPS.—**Septic osteomyelitis,** that is to say, septic inflammation of the medulla of the bone, when the canal has been opened in removing the limb, is one of the most serious accidents that can happen after an amputation. It most frequently occurs during the second week after the operation. The symptoms and pathology are fully described in the Chapter on Diseases of Bone. It was formerly a frequent cause of pyæmia, but with the present improved treatment of wounds it is very rare.

Necrosis.—It not unfrequently happens that a small scale of bone which has been injured by the saw dies, and is separated some three or four weeks after the operation. This is most common in those stumps which unite by second intention, and in which the bone has been bathed in pus for some time. It is said, also, in some cases, to be due to the heat generated by too violent sawing. It is to be prevented by careful sawing, by saving the periosteum as described on page 71, and by the prevention of suppuration by careful antiseptic dressing.

Fig. 29.—Necrosed end of Femur from Stump.

Fig. 30.—Extreme case of Conical Stump.

More extensive necrosis used to be a frequent consequence of septic osteomyelitis, but under the improved systems of dressing it is comparatively rare. In such cases sinuses will be left leading to the necrosed bone, which usually separates three or four months after the operation, the stump then becoming firmly consolidated. The sequestrum in such cases presents the following appearances:—the lower part is thick and annular, and includes the whole thickness of the bone. It is smooth externally, where it has been covered by the periosteum. About an inch or less above this it becomes thinner, is composed of the innermost part of the bone—that which surrounds the medullary canal—and is roughened externally, where it has separated from the adjacent healthy bone; above this it is spiculated and very irregular, becoming gradually thinner (Fig. 29). The part of the bone which escapes necrosis is inflamed, and, as a consequence of osteoplastic periostitis, new bone is deposited abundantly on its surface, leading to a great increase in its thickness, which can be recognised readily through the soft parts.

Conical or "Sugar-loaf" Stumps, as they are called, commonly form, either in consequence of the flaps having been cut too short, or from the soft parts not having been sufficiently retracted before the bone was sawn; but in other cases they may occur, though the stump has been skilfully fashioned, in

consequence of the soft parts, which have been the seat of inflammation and suppuration before the amputation, retracting during the process of healing, so as to denude the bone. In such cases as these, great retraction and contraction of the flaps may go on during cicatrisation, so that the bone may never be covered at all, but be exposed on the surface of an irritable ulcer; or, if the wound does heal, the cicatrix will be unable to support the slightest pressure without becoming ulcerated. In these circumstances, the only remedy consists in laying open the stump, and cutting off about three inches of the bone.

The patient, whose stump is represented in Fig. 30, was under the care of Christopher Heath. The arm had been amputated in the bush in South Africa for an accident. The protruding bone was completely covered by a thin cicatrix. In such cases as this when the patient is a young child, it is probable that the protrusion of the bone is in part due to the continued growth from the epiphysis without a corresponding increase in the soft parts.

Aneurismal Enlargement of the arteries of a stump is very rare. A typical case of this condition has been recorded by Charters Symonds, in which a small aneurism ¾ of an inch in diameter, formed about two inches above the twisted end of the artery after amputation at the knee for injury. The stump healed after prolonged suppuration. Nine weeks after the operation, and two weeks after healing, the sac gave way, and the blood burst through the scar.

Fig. 31.—Aneurismal Varix in Stump.

The patient recovered after ligature of the artery above and below the sac. He had suffered severely from syphilis.

A communication between the divided ends of the artery and veins forming an aneurismal varix has also been occasionally observed. In one case described by Cadge, the communication was between the posterior tibial artery and the venæ comites after disarticulation at the ankle (Fig. 31).

Painful and Spasmodic Stumps.—The nerves in a stump naturally become somewhat bulbous (Fig. 28); and no material inconvenience results from this condition. But it occasionally happens that a considerable enlargement forms in connection with one of them, and attains the size of a cherry or a walnut; and, this being pressed against the end of the bone, the stump becomes the seat of intense pain of a neuralgic character, more particularly whenever it is touched, when a sensation like an electric shock is felt. In such circumstances, excision of this bulbous extremity of the nerve is necessary, and will effect a cure. Sometimes a nervous twig may become implicated in the cicatrix and be compressed by it. Here an excision of the painful part of the scar will remove the pain. Besides this form of painful stump, which may occur in the strongest and healthiest subjects, and is entirely dependent on local causes, there is another condition in which the stump becomes the seat not only of intense pain, but of continuous convulsive twitchings. This form of painful stump arises partly from constitutional causes, and most frequently

occurs in females, more particularly in those who are hysterical or have been subject to neuralgic pains elsewhere. In these cases the general cutaneous sensibility of the stump is increased: it is the seat of convulsive jerkings or twitchings, and the pain is more or less intermittent, being increased under the influence of various emotional and constitutional causes. The treatment of this condition should be conducted on the general principles that will be fully discussed when we come to speak of neuralgia. No excision of the nerves of the stump, or even amputation higher up, is of any avail; the disease, being constitutional, will certainly return in each successive stump, until at last the shoulder or the hip may be reached without any permanent benefit to the patient.

Occasionally after amputation, when healing has been accompanied by suppuration, a condition of chronic or subacute neuritis, with sclerosis of the nerve, is set up, which has a tendency to spread slowly but steadily upwards, finally, perhaps, leading to changes in the spinal cord itself. The symptoms and treatment are those of chronic neuritis, which will be described under Injuries of Nerves.

Recurrence of the Disease for which the Amputation was performed is not of uncommon occurrence in strumous diseases of bones and malignant tumours. In the former case, amputation higher up may be advantageously performed; but in the latter, it is justifiable only when there is no evidence of secondary growths in internal organs or in the lymphatic glands.

Fatty Degeneration of the muscles of a limb, arising from their disuse, gives rise to a peculiar appearance in the stump. During the amputation, the muscles look like pieces of yellow wax, and are firm, but no marked diminution in size has taken place: the fat deposited between the fibres having to some extent compensated for the loss of muscular tissue, so that the general size of the limb and fulness of the muscle are preserved. Union takes place in these circumstances, though somewhat slowly; at least, this has occurred in several cases in which I have observed this condition. In one of these I amputated the leg for disease of the foot of nine years' standing, and in another the thigh for disease of the knee of fourteen years' standing.

MORTALITY AFTER AMPUTATION.

The general causes of death after operations have already been considered; but we must now examine some special points connected with the relative mortality after amputations of different kinds, and the cause of the differences that exist.

Before commencing, however, it would be better in order, as far as possible, to avoid ambiguity, to mention and define the chief causes of death after amputation.

Shock is exhaustion of the nervous centres, the result of violent over-stimulation by the powerful afferent impulse which arises from the injury done to the sensory nerves, either by the knife in amputation or by the injury which rendered the operation necessary. Death usually occurs, in fatal cases, within twenty-four hours. It is aggravated by loss of blood before or during the operation.

Collapse is identical with very severe shock.

Secondary hæmorrhage, as a cause of death after amputations, is usually

limited to those cases in which the bleeding occurs more than twenty-four hours after the operation.

Sloughing of the stump from amputating through injured or diseased tissues is an occasional cause of death.

Septic Diseases.—This term is here used to include all those general or local affections which arise from putrefaction of the discharges of the wound, or from its infection with those specific diseases which are so commonly developed when decomposition of the discharges is not prevented, and too many patients suffering from open wounds are crowded together in too confined a space. The chief varieties are :—(*a*) *Pyæmia*, a general process in which a pyogenic virus (that is to say, a substance capable of setting up suppuration in any part in which it may lodge), derived from a local centre of suppuration, is disseminated through the body by the blood stream. It is characterised by the formation of secondary abscesses in the viscera, joints, and other parts of the body, accompanied by high fever. (*b*) *Septic infection*, which is the infection of the whole system by a virus derived from an unhealthy or foul wound. The virus multiplies in the blood and causes death without giving rise to secondary abscesses. (*c*) *Septic poisoning* or *Sapræmia*, due to the absorption of the chemical products of putrefaction from a foul wound. The term "septicæmia" is used by many writers to include both septic infection and poisoning. (*d*) *Traumatic Fever*, which is a milder form of septic poisoning. (*e*) *Hospital Gangrene*, an acute spreading inflammation, terminating rapidly in gangrene of the affected part. (*f*) *Erysipelas*, an infective inflammation of a specific nature, spreading widely from the wound and accompanied by grave constitutional disturbance. (*g*) *Tetanus*, an infective disease in which a poison is generated locally in the wound, which, being absorbed, gives rise to fatal convulsions. All these diseases are to be attributed directly to foul wounds and overcrowding.

The *Congestive pneumonia* often mentioned as a cause of death after amputations, is most probably always merely an effect of septicæmia, pyæmia, or septic poisoning.

Lastly, one of the commonest causes of death in Hospital reports is *Exhaustion*. This term is used with excessive looseness. Some Surgeons seem even to employ it occasionally as synonymous with shock or collapse. In the majority of cases, however, it really means that the patient is gradually worn out by the profuse discharge from a suppurating wound, combined with chronic poisoning by the absorption of the chemical products of putrefaction. In others it means that the patient died from the effects of severe traumatic fever, of septic origin, commencing on the second day, before he had fully recovered from the shock of the operation. "Exhaustion" doubtless covers, therefore, many conditions which should fairly be included amongst septic diseases.

These causes of death may be divided into the preventible and the unpreventible, and theoretically it may be said that shock is the only one that is genuinely unpreventible. All the septic diseases may be prevented by thoroughly aseptic treatment of the wound, and by proper attention to hygiene. Practically, however, it is not always possible to avoid the "preventible" diseases. The state of the patient's health, the presence of septic complications, bad hygienic surroundings, or the absence of the necessary means for carrying out antiseptic treatment or avoiding overcrowding, may put it beyond the Surgeon's power to save his patient from causes of death which under more favourable circumstances are easily prevented.

The circumstances which specially influence the results of amputations may be divided into three groups :—I. Those that have reference to the constitutional condition of the patient ; II. The occurrence of Shock and Septic Diseases ; and III. Certain conditions special to the operation itself.

I. In the first class the most important are 1, the *Age ;* and 2, the *General Health* of the patient.

1. **Age** exercises an important influence on the result of amputations. As a general rule it may be stated that, the younger the patient, the greater the likelihood of a successful result, though very young children bear loss of blood badly. In youth there is a greater power of resisting the invasion of pathogenic organisms and of withstanding the effects of septic poisoning and loss of blood. The feebler tissues of old people are more readily invaded by pathogenic organisms, and suffer more severely from the irritating effects of the products of putrefaction. The introduction of Antiseptic treatment of wounds has, however, greatly reduced the dangers of amputations after middle life. Volkmann published the results of 48 cases of major amputations performed in patients above 50 years of age. He excluded from consideration all cases in which the amputation was performed during septicæmia, all double amputations, and some few cases in which the patient died from causes independent of the operation. Of the 48 only 2 died : 1 of tetanus, and 1, an habitual drunkard, 60 hours after the operation. The patients' ages were, in thirty cases between 51 and 60 ; in thirteen, between 61 and 70 ; in four, between 71 and 80 ; and one patient, aged 84, recovered from an amputation at the knee. Although the exclusion of all complicated cases makes these statistics more favourable than they would otherwise have been, the results show that under the improved treatment of wounds, a fair degree of success may be obtained even in very advanced life, provided that old age is the only unfavourable condition present.

2. The **General Health** of the patient previous to the operation exercises a most powerful influence on the chances of recovery. The state of the kidneys, more especially, is of great importance ; for no condition tends more certainly to a fatal termination than chronic disease of those organs. The results of amputation necessarily differ widely, according as the operation is practised on the healthy inhabitant of a country district, or on the cachectic and debilitated denizen of a large town.

II. 1. The occurrence of **Shock.**—Out of a total of 631 amputations collected from the reports of some of the Metropolitan hospitals between 1866 and 1872, 239 deaths occurred, and of these almost exactly 10 per cent. were due to shock. Out of 80 consecutive cases at University College Hospital during the same period, 3 died from shock. This cause of death is but little under the control of the Surgeon, and it can hardly be hoped that the rate of mortality due to it can ever be materially diminished. The influence of shock is necessarily most felt in primary amputations. Indeed, its fatal results are almost confined to amputations performed within twenty-four hours of the infliction of the injury. It occurs in exact proportion to the severity of the injury, the amount of loss of blood, and the age of the patient. It is often referable rather to the injury than to the operation ; and it becomes a question whether, in many cases of hopeless smash of a limb, it might not be better to let the patient die in peace than to subject him to the repetition of a shock which he will be utterly unable to endure. This is more especially the case

in extensive crush of the lower extremity up to or above the middle of the thigh, such as is not uncommon from railway accidents. Amputation through the upper third of the thigh, or at the hip-joint, is then the only available operation, and it is often done; but I am not acquainted with a single case in which it has succeeded in men who have arrived at full maturity. In children and young adults it has proved successful.

As death from shock, after primary amputations, happens usually within twenty-four hours of the performance of the operation, it cannot in any way be affected by the conditions to which the patient is exposed after the operation, so far at least as hospitals or other external influences are concerned. We may, therefore, look upon death from shock as a part of the accident to which the person has been exposed, aggravated, doubtless, by the further depressing influence of the operation. Death from shock necessarily occurs more frequently under similar conditions of injury at advanced than at early periods of life. It is interesting also to observe that season exercises an influence on the liability to death from shock after primary amputations. According to Hewson, of Philadelphia, it is most fatal in winter, the cold, to which the sufferer has been exposed after the accident, acting as an additional cause of depression.

The only way therefore to diminish the proportion of deaths from shock is not to amputate in hopeless cases in order to give "a last chance" to a patient whose vital powers have already been depressed to the lowest ebb by a fearful mutilation. Such amputations which sometimes consist in little more than the severance of a limb still attached to the trunk by shreds of muscle, ought scarcely to find their way into a statistical table professing to give the results of operations the majority of which are performed more deliberately, and with a better prospect of success. They ought, in fact, to constitute a class of cases apart; the more so, as they are frequently complicated with internal injuries which are not detected until after the death of the patient.

Shock, as has already been shown, exercises its influence chiefly in primary amputations, far less in secondary ones; and disappears entirely as a cause of death, in pathological amputations, except in a few cases of such operations as amputation at the hip-joint or shoulder-joint in patients already greatly enfeebled by disease.

2. **The development of some form of "septic disease,"** is, however, far more important than shock as a cause of death after amputation, first because in former times these diseases proved fatal in a considerable proportion of all cases operated on, and secondly, because they are to a great extent, if not altogether, preventible. The terrible frequency of these diseases a few years ago is shown by the fact that out of the 631 cases of amputation before mentioned no fewer than 86 died from one form of septic disease alone—pyæmia—irrespective of those who are reported as having died of "exhaustion," septicæmia, erysipelas, and "low cellulitis." Of the 80 cases from University College Hospital ten died of pyæmia alone. The influence of this disease on the death-rate was found not only to vary greatly according as the operation was primary, secondary, or for disease, but also to differ considerably in different hospitals. Above one-third of the deaths amongst the primary amputations were from this cause. In the secondary amputations 44·4 per cent. of the deaths were from pyæmia, and in those for disease 34·6 per cent., an amount nearly equal to that of the primary operations.

The foregoing statements justify us in believing that, if septic diseases could be prevented, no patient, who at the time of the operation is in good general health, should die of an amputation if he survive the period of shock, unless it be from the weakness of extreme old age. Secondary hæmorrhage is almost as preventible as pyæmia by the exclusion of septic influences. The value of the majority of amputation statistics is greatly impaired by all the cases being put together with no further separation than into primary and secondary, and we thus get a very false notion of the mortality occurring in ordinary cases. Some very valuable statistics have been published by Max Schede, in his work on Amputations, in which this source of error has been eliminated by following the classification of cases suggested by Volkmann. The cases are divided first into "Complicated" and "Uncomplicated." The Complicated cases, which are classed separately, are—Multiple or Double Amputations; cases complicated with other severe injuries; cases in which the patient was suffering from severe surgical fever, septicæmia, pyæmia, spreading gangrene, or tetanus, at the time of the operation; and, lastly, cases which terminated fatally, or in which the cure was incomplete after many months, on account of acute intercurrent diseases, such as delirium tremens, acute pneumonia (not of septic origin), or chronic diseases, such as phthisis, Bright's disease, amyloid degeneration, secondary cancer, &c.

Secondly, the cases are divided into those treated antiseptically and those belonging to a period before the introduction of antiseptics and systematic drainage into the treatment of amputation wounds. The former are taken from the published statistics of Socin of Bâle, Volkmann of Halle, and Max Schede in Berlin; the latter from those of Bruns of Tübingen, Bardeleben, then of Greifswald, and Billroth, then of Zürich. The cases treated by the older methods showed the following results :—

	CASES.	DIED.	PER CENT.
Uncomplicated cases	377	110	29·18
Double amputations	10	3	30·00
Complicated by other injuries	5	4	80·00
" by Septicæmia, Tetanus, &c.	48	40	83·33
" by constitutional diseases	21	21	100·00
Total	461	178	38·83

These are not worse than the average statistics of amputations twenty or twenty-five years ago.

The cases treated antiseptically by carbolic acid dressings and all the precautions recommended by Lister, show the following results :—

	CASES.	DIED.	PER CENT.
Uncomplicated cases	321	14	4·4
Double amputations	13	3	23·8
Complicated by other injuries	11	8	72·72
" by Septicæmia, Pyæmia, Tetanus, &c.	45	30	66·66
" by constitutional diseases	27	16	59·26
Total	417	71	17·02

The causes of death in the uncomplicated cases are equally instructive:—

CAUSE OF DEATH.	OLD TREATMENT. 377 Cases.	ANTISEPTIC TREATMENT. 321 Cases.
Pyæmia	72	0
Septicæmia	19	1
Erysipelas	2	1
Tetanus	0	1
Pyæmia simplex	6	1
Secondary hæmorrhage	3	1
Old age	2	1
Shock	6	8
Total	110	14

The disease classed here as pyæmia simplex is blood poisoning, arising from a suppurating wound without the formation of secondary abscesses. It would be classed by many authors as septic infection.

Results even superior to these have been obtained at Newcastle-on-Tyne Infirmary by the use of antiseptics. Frederick Page has published the results of all the amputations performed in that institution from 1878 to 1891. They amount to 687, with a death-rate of only 8 per cent. The cases are not classified in the way above mentioned. If this were done, the death-rate in the uncomplicated cases would be probably less than 4 per cent.

The following are the statistics of amputations performed in University College Hospital during the twenty years 1871 to 1890 inclusive. They are divided into four periods of five years each. In the first period the majority of the cases were treated without antiseptics. In the last period every case was dressed with some efficient antiseptic dressing. The particular antiseptic used varied in different cases. Many stumps were most successfully treated by lasting dressings of iodoform or salicylic wool.

	1871—1875.		1876—1880.		1881—1885.		1886—1890.	
	CASES.	DIED.	CASES.	DIED.	CASES.	DIED.	CASES.	DIED.
Uncomplicated cases:—								
For injury, primary	33	10	22	2	23	2	15	0
„ secondary	10	1	8	2	1	1	3	0
For disease	58	11	66	15	63	9	52	2
Total	101	22	96	19	87	12	70	2
Deaths per cent.		22		19·5		13·8		2·85
Complicated cases:—								
Double amputations	6	3	3	1	—	—	1	1
Other fatal injuries	2	2	—	—	1	1	—	—
Amputation during tetanus	1	1	—	—	—	—	1	1
„ „ septicæmia	—	—	—	—	1	1	3	2
„ „ erysipelas	1	0	—	—	—	—	—	—
„ „ gangrene	—	—	2	1	3	1	7	2
In patients suffering from grave constitutional disease, phthisis, Bright's disease, albumenoid disease, &c.	9	5	6	5	2	2	3	2
Totals of all Amputations	120	33	107	26	94	17	85	10
Deaths per cent.	—	27·5	—	24·29	—	18·08	—	11·75

The causes of death amongst the uncomplicated cases were as follows :—

CAUSES OF DEATH.	1871—1875.	1876—1880.	1881—1885.	1886—1890.
Pyæmia	9	4	0	0
Septicæmia	3	7	2	0
Erysipelas	1	0	0	0
Shock	5	5	3	2
Exhaustion	1	0	1	0
Sloughing of stump	3	2	2	0
Secondary hæmorrhage	0	1	2	0
Cardiac thrombosis	0	0	1	0
Tetanus	0	0	1	0
Total	22	19	12	2

Of the 17 fatal cases in the third period five were amputations at the hip-joint and two at the shoulder-joint. The two deaths in the uncomplicated cases in the last period were after amputation at the hip-joint.

These tables show a satisfactory and progressive diminution in the death-rate, especially in that arising from septic diseases. In fact, there has not been a death from pyæmia after amputation in University College Hospital since 1880. Another interesting feature in these statistics is the great diminution in the number of secondary amputations in the last ten years, showing the success that has attended the treatment of compound fractures. The total number of amputations has also considerably diminished ; by no less than 30 per cent. if we compare the last five years with the first. This also is evidently in great part due to the success attending conservative surgery after injury. The amputations for disease have also considerably diminished in proportion to the patients admitted, for in 1879 about twenty surgical beds were added to the hospital. The number of amputations for disease of the knee is, in the last period, only half what it is in the first—another evidence of the advance of conservative surgery.

The amputation mortality in my wards, from 1850 to 1873, was 40·7 per cent. for injury and 18·1 for disease, on an aggregate of 387 cases, being 25·8 per cent. for all cases.

Although the improvement that has taken place generally in the amputation mortality is no doubt chiefly due to the employment of antiseptics, the better hygienic arrangements of modern hospitals cannot be ignored as a factor in lessening the liability to the generation of septic diseases. Many Surgeons also, who have not adopted any special antiseptic method of treatment, have achieved, by a careful selection of cases, by improved methods of operating, by perfect drainage and rest, and great attention to cleanliness, results which have rarely been surpassed. Spence, of Edinburgh, had once a run of 63 consecutive amputations with only three deaths. Amongst the most excellent results of this class that have been published, are those of Borland, of Kilmarnock, who out of 25 major primary amputations (double amputations being excluded), had 6 deaths, or 24 per cent., and in 63 amputations, secondary and for disease, only 2 deaths, or 3·1 per cent. These results were obtained without chemical antiseptics, by avoiding the use of water during the operation, the blood being wiped away with pieces of clean rag, and by leaving the wound to glaze before bringing the flaps together, with perfect rest of the stump, which was dressed with a thin piece of rag smeared with lard, any discharge that formed being wiped away.

III. The circumstances connected with the amputation itself that influence materially its result are: 1. Its *Seat*. 2. The *Structure of the Bone* sawn. 3. Whether for *Injury* or *Disease*. 4. If for disease, the *Nature* of the affection. 5. If for injury, the *Time* that has elapsed before the operation.

1. With regard to the influence of the **Seat** of amputation on the result as a general rule, the risk increases with the size of the part amputated, and as the line of amputation approaches the trunk; in fact, the nearer it is to the trunk, the greater is the danger. This is clearly shown by the subjoined table, derived from the statistics of amputation in various British, Continental, and American hospitals.*

SEAT.	CASES.	DEATHS.	PER CENT.
Shoulder-joint	117	58	49·5
Arm	1319	375	28·4
Fore-arm	1059	109	10·2
Hip-joint	46	19	41·3
Thigh	3477	1224	35·2
Leg	3005	985	32·7

The death-rate in the above table is higher for each operation than it would be at the present time, as the following statistics from University College Hospital serve to show:—

SEAT.	CASES.	DEATHS.	PER CENT.
Shoulder-joint	19	6	31·6
Arm	30	4	13·3
Fore-arm	49	8	16·3
Hip-joint	16	12	75·0
Thigh	151	35	23·1
Leg	100	14	14·0
Ankle	42	2	4·7

The higher death-rate in the amputations of the fore-arm was due to the fact that two were cases of disease in extreme old age, and two were performed as a last chance of saving a case of tetanus.

If we turn to the records of military surgery we find similar results. In the war of the American rebellion the percentages of mortality were as follow, showing markedly how rapidly it runs up in accordance with the size of the part removed: fingers and hand, 1·6; wrist, 5·5; fore-arm, 16·5; arm, 21·2; shoulder, 39·2; partial of foot, 9·2; ankle-joint, 13·4; leg, 26; knee, 55; thigh, 64·4; hip, 85·7.

Not only is there this increase in the rate of mortality as the operation approaches the trunk, but in the larger limbs, more especially in the thigh, every additional inch that is removed appears to make a difference in this respect. Thus, in our army in the Crimea, of 178 amputations of the thigh, 44 were in the upper third, and of these 38, or 86 per cent., proved fatal; 68

* The reader who may wish for fuller details of the statistics of amputations in the past and in modern times, may refer to the Tables published in the last edition of Cooper's "Surgical Dictionary," by Mr. James Lane; Sir J. Y. Simpson's "Papers on Hospitalism;" M. Chenu's elaborate returns on the Medical Service of the French Army in the Crimean War and in the Italian Campaign; the Official Reports of the United States Army in the War of the Rebellion; and Max Schede's work on "Amputations" in Billroth and Pitha's Surgery.

were in the middle third, and of these 41, or 60 per cent., died; whilst in the lower third the mortality out of 66 cases was 37, or 56 per cent.

The size of the part removed and its proximity to the trunk have also considerable influence on the cause of death. Thus after the smaller amputations death occurs only in unhealthy states of the constitution, or from the occurrence of erysipelas, or of some other infective process originating in the wound. In the larger amputations in addition to these causes of death, shock is frequently fatal, often aggravated by loss of blood before or during the operation. The larger the vessels divided the more likely is secondary hæmorrhage to occur.

2. The **Part of the Bone** that is sawn through may influence the result. Whenever the medullary canal is opened, if the patient be exposed to bad hygienic surroundings, and putrefaction of the discharges be not prevented, there is danger of septic suppuration taking place in the medulla, a condition very frequently followed by pyæmia. Amputations through the cancellous ends of long bones are comparatively free from this danger, and consequently show a lower mortality. In disarticulations this complication can hardly occur.

3. The mortality resulting from amputations is influenced to a great extent by the **Cause** for which the operation is performed, being far greater in corresponding parts after injury than after disease. The fore-arm and ankle, however, seem to be exceptions to this rule, for the reason that amputations in these regions cause little shock, and the vessels divided are small, and secondary hæmorrhage is rare. Thus two important causes of death are eliminated, and a healthy patient usually recovers. When the amputation is performed for disease, however, it is most commonly in cases of tuberculous caries, in which, owing to the general condition, other means have failed to cure.

The following table gives the result of numerous cases in civil practice, collected from various sources. (See note, p. 86.)

SEAT.	*Injury.*			*Disease.*		
	CASES.	DEATHS.	PER CENT.	CASES.	DEATHS.	PER CENT.
Thigh	964	576	59·7	1465	477	32·5
Leg	771	356	46·1	1281	301	23·5
Arm	514	180	34·4	250	65	26·0
Fore-arm	360	38	10·5	151	23	15·9

The following statistics from University College Hospital, being of more recent date, show somewhat better results:—

SEAT.	*Injury.*			*Disease.*		
	CASES.	DEATHS.	PER CENT.	CASES.	DEATHS.	PER CENT.
Hip	2	1	50·0	14	11	78·4
Thigh	31	12	38·7	120	23	19·1
Leg	44	9	24·5	56	5	8·9
Ankle	6	0	0	36	2	5·5
Shoulder	6	3	50·0	13	3	23·0
Arm	20	1	5·0	10	3	30·0
Fore-arm	24	4	13·3	25	4	16·0

The *Shock* inflicted by the injury, with its subsequent evils, is the principal reason for the greater mortality after amputations for injury than after those for disease. After amputation for injury, also, there is a greater liability to the occurrence of gangrene of the stump, as the incisions may be carried through tissues which, though apparently sound, may be so bruised as to be beyond recovery. Pyæmia, formerly as frequent in primary as in secondary amputations, should now be equally rare. Exhaustion is more frequent after removal of a limb for disease, as in many cases the operation is necessarily performed on patients already weakened by long illness. In many forms of disease, however, especially in affections of bones and joints, it will be found that those patients do best in whom the disease is most chronic.

4. The **Nature of the Disease** for which the amputation is performed influences its mortality. Amputations for malignant growths are more fatal than those for diseased joints. This is probably due to the fact that the malignant growths have often given rise to secondary growths in the viscera before the operation was performed. In amputation for tubercular diseases of bones and joints similar disease of the internal organs is not uncommonly found should death occur. When a limb is removed for acute septic suppuration of a joint, a fatal result is of frequent occurrence, especially if the affected articulation be a large one, such as the knee. In these cases the patient is usually suffering from severe febrile disturbance, the result of absorption of septic matter from the diseased joint, and amputation under such circumstances is frequently followed by fatal septicæmia. But when the disease has once become chronic, the precise period at which the amputation is performed exercises but little influence on the mortality, provided it be not deferred to too late a stage, when the patient's constitution is worn out by hectic.

Amputations of expediency—those performed for the convenience of the patient, as in cases of talipes or ankylosis—have been said to be especially fatal. Bryant, in 1859, showed that at Guy's Hospital, death had followed in 40 per cent. of these amputations in the lower extremity. There is no reason, however, to believe that this is true of such amputations at the present time. In fact, as such amputations must necessarily come into the uncomplicated class, a fatal result ought to be a rare and exceptional occurrence.

5. In amputation in case of injury an important question has to be determined, viz., the influence exercised by the **Time** that has elapsed from the infliction of the injury to the performance of the amputation. Not only the rate of mortality, but the conditions that immediately occasion the fatal event, are influenced by the period at which the operation is performed.

Amputations for injury are commonly divided by Surgeons into *Primary* and *Secondary;* the *primary* being those that are performed during the first twenty-four or thirty hours, before any spreading inflammation or traumatic fever has developed itself. By *secondary* amputations many Surgeons mean those operations that are practised after the first twenty-four hours; whilst others again more correctly restrict the term to those that are done after suppuration has been fully established, and the surgical fever is beginning to subside as granulation tissue springs up to present a barrier to the absorption of the septic poison. Those who thus limit the use of the term *secondary*, call all the operations performed between the end of the first day and the period of full suppuration "intermediate." The distinction is of some importance, as operations performed during high surgical fever are extremely

fatal. In the following tables, the cases are divided merely into primary and secondary. The first is from my own practice at University College Hospital. During the last fifteen years, owing to the great success attending the antiseptic treatment of compound fractures, secondary amputations have been so rare that no statistics of any value can be added. The cases in the second table have been collected from various sources, and refer to civil practice before 1870.

RESULTS OF PRIMARY AND SECONDARY AMPUTATIONS IN CASES OF INJURY, AT UNIVERSITY COLLEGE HOSPITAL. (1869.)

SEAT	*Primary.*		*Secondary.*	
	CASES.	DEATHS.	CASES.	DEATHS.
Thigh . . .	14	8	21	14
Leg and Foot . .	22	8	16	3
Shoulder and Arm .	6	2	5	2
Fore-arm . . .	6	0	1	0
Total . . .	48	18	43	19

SEAT.	*Primary.*			*Secondary.*		
	CASES.	DEATHS.	PER CENT.	CASES.	DEATHS.	PER CENT.
Thigh	235	153	65·1	156	85	54·4
Leg	405	178	43·9	150	72	48·0
Arm	276	79	28·6	75	32	42·0
Fore-arm . . .	190	16	8·4	27	6	22·2
Total . . .	1106	426	38·5	408	195	47·7

When we consider that the secondary amputations are almost exclusively derived from cases in which an attempt to save the limb has failed on account of extensive sloughing of the soft parts, gangene of the limb from injury to the vessels, profuse suppuration, septic osteomyelitis, necrosis of the bones, or threatened death from exhaustion or septic poisoning, it is not surprising that they are followed by a higher proportion of deaths than primary operations. In primary amputations high up in the thigh for injury, shock, more due to accident than the operation, is so commonly fatal, that the proportion of deaths is higher for primary than secondary amputations in this region. We must not conclude, however, that the patient's chance of life would be increased by leaving the mangled limb on in the hope of his surviving to a secondary amputation. Death from shock would probably occur, as the presence of the limb would prevent rallying and be as fatal as the operation. In any secondary operation, should the patient survive the period of shock, the condition of the limb at the time of amputation necessarily increases the risk of pyæmia, septicæmia and secondary hæmorrhage. The deaths from these causes are therefore more common in secondary amputations, while shock is more frequent in primary operations.

In military practice, secondary amputation is also more fatal than primary. In the British army in the Crimea, the relative rates of mortality per cent. after primary and secondary amputations, were as follows:—after *primary*

amputations at the shoulder, 26; of the arm, 17; of the fore-arm, 3; of the thigh, 62; of the leg, 30; and of the foot, 17; after *secondary* amputations at the shoulder, 66; of the arm, 31; of the fore-arm, 28; of the thigh, 80; and of the leg, 76. That is to say, for the upper extremity, the whole rate of deaths after primary was 15, against 41 after secondary amputations; whilst, for the lower extremity, excluding the foot, it was 46 per cent. for the primary, as against 78 for the secondary. In the American army during the Civil War. the mortality after primary amputation of the thigh was 54·13 per cent.; and after secondary amputation, 74·76. It will be noted that the primary amputations of the thigh are far less fatal than the secondary, the reverse of the relative proportions met with in civil practice. The explanation of this is probably that the shock caused by a bullet-wound is less than that following the severe crushes common in civil practice, as for example that caused by a railway accident. Primary amputations in military practice are moreover frequently done on the field of battle, and the patient is treated in a tent or in a pure house; secondary operations are more often performed in crowded hospitals or in houses ill adapted for the purpose, which have been overfilled with wounded for a week or ten days after the battle. The primary amputations are in great part healed before the effects of overcrowding and accumulation of suppurating wounds become fully developed; the secondary operations are performed just when these evils are reaching their maximum. In future wars it is to be hoped better results will be obtained by the use of antiseptics, but it is hardly to be expected that overcrowding and foul wounds can be altogether avoided; and under these circumstances the Surgeon will do better for his patient by giving him the benefit of a primary amputation in every doubtful case, than by attempting to save the limb trusting to a secondary operation in case of failure.

SUMMARY.—On reviewing the whole subject of the causes of death after amputations, we cannot but come to the conclusion that the mortality is influenced chiefly by the success or failure in the prevention of septic processes in the discharges of the wound, and by the hygienic conditions to which the patient is subjected after the operation. The evil influences arising from exposure to an atmosphere vitiated by the emanations from the decomposing discharges of suppurating wounds, and to those various combinations of conditions that are summed up under the general term "*Hospitalism*," have so important a bearing upon the death-rate after amputation, that, in order to arrive at a just estimate of the probable chances of recovery in any given case, it becomes necessary to consider not only whether the operation be done for injury or disease—whether it be primary or secondary—whether the disease be simple or malignant—whether the patient be aged or young, healthy or diseased; but, above all, whether, after the removal of the limb, the patient will be exposed to those conditions that result from the aggregation of the sick and the crowding together of foul suppurating wounds.

Whatever explanation we may give of the fact, it remains certain and incontrovertible that the rate of mortality after amputation of all limbs in the large city hospitals of Great Britain up to a comparatively recent period has been at least 1 in 3. In those of Paris, out of 1,656 amputations, the statistics of which were collected by Malgaigne and Trélat (Simpson), 803 died, or nearly 1 in 2. The Government statistics collected by Bristowe and Holmes

show that in 1861 the amputation death-rate in Parisian hospitals was 3 in 5, and more recently Le Fort gives the mortality at 58 per cent. In Germany matters were no better. Billroth's published amputation mortality was at one time from 43 to 46 per cent. In the United States, however, the death-rate was much smaller; the mortality in the Pennsylvania Hospital being only about 24 per cent., and that in the Massachusetts General Hospital 26 per cent.

In military practice, the result of the experience deduced from the mortality following amputations during the great modern wars is at least equally unfavourable. But here there are so many modifying and disturbing elements that it may be well to exclude these cases from consideration.

In fact, then, on taking the average mortality after amputation in the largest hospitals in the great centres of civilisation, we come to this result, that it commonly varied from 60 to 35 per cent., and did not fall below 24 per cent.; and that in certain of the larger amputations, as in the upper third of the thigh and at the hip-joint, it ran up to from 70 to 90 per cent. Widely extended statistical returns showed but too plainly that these figures were trustworthy and constant.

So constantly did these figures come out in hospital returns, that Surgeons had almost come to regard them as representing the necessary, or, so to speak, the *natural* rate of mortality after amputations. But that it was not necessary —that it was dependent on preventible causes, was maintained by Callender, Lister, Spence, and others who, by different methods of treatment, but all having in view attention to the hygienic conditions of the wound and of the patient, obtained results far better than those formerly prevailing. Such results are now no longer exceptional.

The statistics quoted in a former page from Max Schede's work on amputations show what can be accomplished by the antiseptic treatment. The system adopted by the Surgeons, from whose practice those statistics were collected, was that recommended at the time by Lister. It matters little, however, what method of dressing is adopted, so long as the decomposition of the discharges is absolutely prevented. This is the principle of antiseptic surgery; but the best means of carrying it out has probably yet to be discovered. Whenever antiseptic treatment is efficiently carried out, by whatever means it may be accomplished, the wound ceases to be a source of infection and of contamination to the surrounding atmosphere, and the results of hospital practice then equal the best that can be obtained in private.

Up to 1869 Surgeons had no opportunity of obtaining a knowledge of the results of amputations on a large scale, except such as had been furnished by the statistical reports of hospitals; but in that year Sir James Simpson collected from small country hospitals, and from private practice in manufacturing and mining districts, in which amputations are of common occurrence, statistics which proved satisfactorily that in the time before the modern improved methods of treating wounds were fully understood, the aggregation of patients suffering from open wounds in one building exerted a powerful influence on the proportion of deaths.

Simpson collected the particulars of 2,098 amputations of all kinds occurring in the country and in private practice in towns; of these 229 died, or 1 in 9·2; whilst of an almost equal number, viz., 2,089 amputations, performed in the large city hospitals of Great Britain, 855 died, or 1 in 2·4.

It is probable that Simpson's figures were not absolutely but only approximately correct, and that certain sources of fallacy had intruded themselves, more especially with regard to the condition of the patient *before* the operation, to which undoubtedly great importance must be attached (*vide* p. 81). But still, making full allowance for all this, the difference between the two sets of cases is so great, that the conclusion that the mortality after amputation in hospital practice was nearly four times as great as when the same operations were performed out of hospital, cannot be very materially affected; and it was impossible to escape from the inference that the high hospital mortality was greatly influenced by the exposure of the patient to those septic conditions existing in the air of large hospitals, which have been so ably and graphically described by Parkes, and which exercise the most injurious effect on patients with large wounds who are exposed to them.

That in the absence of efficient antiseptic and hygienic precautions those septic influences may eventually saturate hospitals, and exercise a most important influence in causing fatal pyæmia, septicæmia, and osteomyelitis, after amputations, from which, as has already been shown, a large proportion of those operated on formerly died, is evident from the following considerations:

1. From the commencement of this century up to a comparatively recent period—during what, in fact, may be termed the pre-antiseptic age—no improvement had taken place in amputation mortality in hospitals.

2. The prevailing high rate of mortality varied greatly in different hospitals in the same town, in which the patients were of the same class of society, followed pretty much the same occupations, and were subjected to the same kinds of injuries and diseases; the hospitals being officered by Surgeons of equal professional skill, and the only inequality existing being in the different conditions to which the patients were exposed in different hospitals.

3. The difference in the amputation mortality in different London hospitals varied from 18 and 25 to 47 per cent. In Calcutta, the death-rate after thigh amputations varied in different hospitals from 42 to 80 per cent. (Downie).

4. Of late years, this excessive amputation mortality has been greatly reduced in all hospitals.

5. This reduction is contemporaneous with, and, *as all the other conditions continue as before*, is dependent upon, the employment of antiseptics in the treatment of wounds, and the greater attention paid to hospital hygiene.

6. In military practice, the rate of mortality after amputation has been found to be in the direct ratio of the aggregation of the wounded; and infective processes of septic origin may to a very great extent be averted by isolation of the patients.

CHAPTER III.

SPECIAL AMPUTATIONS.

There are, as has already been stated at pp. 59, 61, 70, three distinct methods of amputating limbs, viz., the flap, the circular, and the oval. A skilful Surgeon will be able to produce a satisfactory stump by any one of the three methods, and it is desirable that he should be able to practise all. For although, as a general rule, one method may be more applicable than another, yet exceptional cases occur in which it may be advantageous to depart from the method usually adopted, and employ one of the others. In fact, the Surgeon should select that which is most suitable to the circumstances of the case before him. The flap method, or the combined flap and circular, is that to which most Surgeons give the preference in this country.

In describing any method of amputating, precise rules may be laid down for its performance through sound structures; but it often happens, especially in cases of injury, that the destruction of tissue is so irregular as to compel the Surgeon to shape his flap as best he may from the uninjured parts; but so efficient is the moulding process of nature, that provided sufficient covering be left on the muscles and bones, a stump that at first looks irregular and unsurgical, will soon acquire a regular outline, and may be eventually in all respects as useful as one fashioned at first more artistically.

Amputations of the Hand.—The **Fingers** often require amputation for injury or disease, more especially as the result of bad whitlow. When the ungual phalanx becomes necrosed, it may usually be removed without amputation, by an incision through the pulp of the finger, thus saving the nail and pulp, which will form an excellent end to the finger. If the operation be done in early childhood, a new and movable phalanx may form. Should amputation be required, it may either be done by opening the joint from its dorsal aspect with a narrow-bladed bistoury, and making the flap from the palmar aspect by cutting from within outwards: or the flap may be made from the palmar surface by transfixion, and the joint opened from the palmar aspect (Fig. 33). In amputating the ungual phalanx from the dorsal aspect, the Surgeon must stand facing the hand; the finger must be flexed forcibly, so that the last phalanx is at a right angle to the next. The incision to open the joint must be made in continuation of an imaginary line drawn along the side of the second phalanx, midway between the dorsal and palmar aspects. It must commence at the crease opposite the joint, and finish at the corresponding point on the other side, the Surgeon cutting from his left to his right side of the finger. As the joint opens, the lateral ligaments must be touched with the point of the knife. As these are divided, the first two phalanges must be extended while the ungual phalanx is still further flexed. The knife is then passed with a sawing motion towards the palmar surface of the phalanx, the edge being turned slightly

towards the bone. Finally the ungual phalanx is to be fully extended, and a flap cut including the whole pulp (Fig. 32). When any difficulty is experienced

Fig. 32.—Amputation of Part of a Finger by cutting from Above.

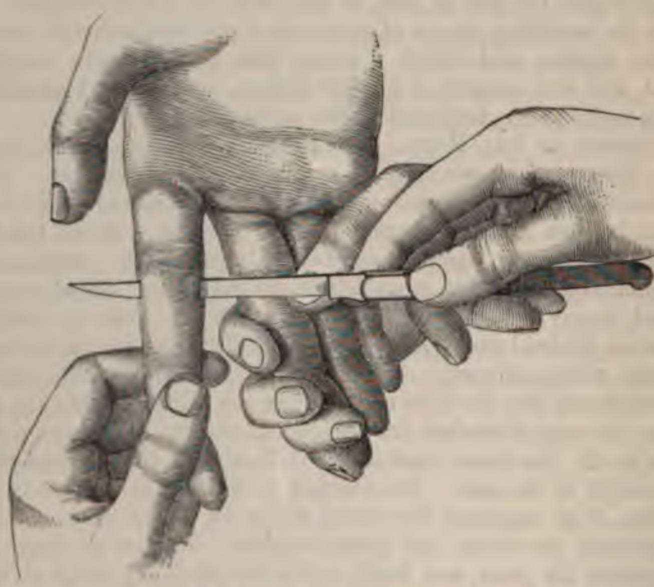


Fig. 33.—Amputation of a Finger. Cutting the Flap by Transfixion.

in finding the joint, it is either from taking a wrong line, or from the presence of a small rheumatic exostosis on the base of the ungual phalanx.

In amputating by transfixion from the palmar surface, the finger must be

extended with the palmar surface towards the Surgeon. The knife must be made to transfix the finger as close to the bone as possible, and in such a way that the back is one-eighth inch on the distal side of the crease corresponding to the joint. A flap of sufficient length is then cut, which must be raised and held out of the way by an assistant. The joint is then opened, the operator bending the last phalanx forcibly backwards to put the anterior ligament on the stretch. Finally, the phalanx is removed by carrying the knife through

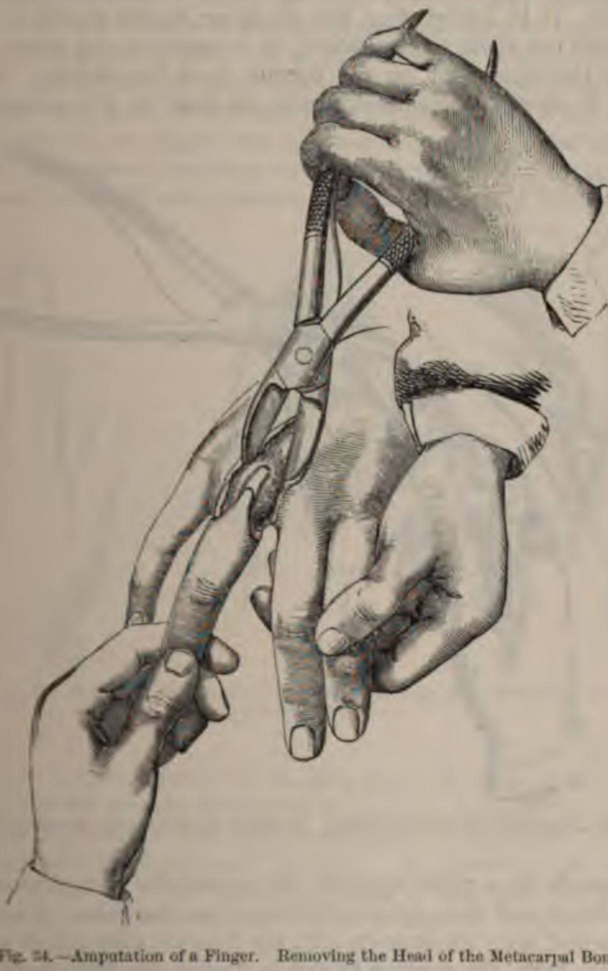


Fig. 34.—Amputation of a Finger. Removing the Head of the Metacarpal Bone.

the joint, no flap being made from the dorsal aspect (Fig. 33).* In doing this care must be taken to avoid cutting too high up and so mistaking the depression above the head of the second phalanx for the articulation.

Amputation is performed between the proximal and second phalanges in the same way; but as a stump composed of the first phalanx is of but little use, it is more common to remove the whole finger. In the hand of a working

* For the Conservative Surgery of the Hand, *vide* chapter xlvii.

man, however, it is better to save even one phalanx, as it helps somewhat to strengthen the grasp; for the stump can be strongly flexed, partly by the action of the interossei and partly by the long flexors which form new attachments at its extremity. In the case of the index finger, it will be better always to leave the proximinal phalanx, the stump of which forms a useful opponent to the thumb.

Amputation is frequently required at the **Metacarpo-phalangeal Articulation.** Here it may be done in two ways: either by lateral flaps, or by the oval method. If by *lateral flaps*, the adjoining fingers should be well separated from the one about to be removed, by an assistant who grasps the hand, so as to put the integument on the dorsum upon the stretch. The point of a bistoury is entered immediately above the head of the metacarpal bone,

Fig. 35.—Amputation of the Index Finger. Removing the Head of the Metacarpal Bone.

carried forwards to a point opposite the interdigital web, drawn across the side of the finger, and then carried a little way into the palm. This same process is performed upon the opposite side, the flaps are dissected down by a few touches of the knife, the extensor tendon is divided, the joint opened, and disarticulation performed. The *oval method*, which is undoubtedly the better, as it does not wound the palm, consists in entering the bistoury at the same point as in the last case, carrying it as far as the point at which the web joins the finger which is being taken off, on the operator's right hand side; then across the palmar aspect, in the line of the fold in the skin at the root of the finger, to the web on the other side. Thus far the incision may be made without taking the knife out of the wound. The oval is completed by putting the point of the knife in the end of the first incision and carrying it upwards to

the starting point, the Surgeon's hand and the handle of the knife, during this second part of the operation, being over the back of the patient's hand. The two sides of the oval should be exactly symmetrical, and the incisions from the starting point to the web should not be straight, but slightly curved in such a way that their convexities look towards the middle line of the finger which is being removed. By a few touches of the knife the oval flap is turned back: the flexor tendon is then divided and the articulation opened from the operator's right hand side; finally the finger is removed by twisting it round, while the edge of the knife is pressed against the base of the first phalanx with a slight sawing movement. As a general rule, it is better not to remove the head of the metacarpal bone with the finger, as by so doing the hand is narrowed and weakened. If the head be left, a gap of some width will remain in the situation of the finger that has been amputated; and should it be desirable for any reason to attempt to diminish this deformity, the head may be taken away in the following manner. The incision must be commenced on

Figs. 36, 37, 38.—Results of Amputation above Metacarpo-Phalangeal Articulation in Middle, Index, and Ring Fingers.

the dorsum about three-quarters of an inch above the head of the metacarpal bone, and be carried straight downwards to a point opposite the head, where an oval incision, similar to that above described, is commenced. We thus get what is known as a "racket-shaped" incision. In removing the middle and ring fingers, it will be found more convenient to take out the head of the metacarpal bone after disarticulation. This is done by cleaning the dorsal surface and sides, taking care to keep close to the bone, and not to let the point of the knife plunge into the palm, so as to wound a digital branch at a point where it could with difficulty be secured. The bone-forceps are then applied, in a transverse direction, immediately above the head of the bone (Fig. 34). The operator then places the tip of his fore finger in the palm of the hand, so as to push the separated head slightly out of the wound, while, at the same time, he drags it downwards with his thumb placed on the cut surface of the bone. By a few touches of the point of the knife it is easily turned out, and with the slightest care all risk of wounding a digital branch is avoided. If it be the index finger, the bone should be cut obliquely, so as to shape it to

the tapering form of the hand (Fig. 35). This may be done either with the bone-forceps or with a small saw. The saw has the advantage of making a smoother section and of leaving no splinters. If the bone be cut directly across, an ugly and inconvenient square protuberance, liable to constant injury, will be left. When, however, the patient's employment is one in which great strength and breadth of hand are required, and where appearance is of little consequence, the head of the bone should not be removed.

In amputating the little finger, with the head of the metacarpal bone, the incision must be commenced at the inner side of the hand, at a point corresponding to the middle of the shaft of the bone, and carried straight downwards to a point opposite the head, from which the oval must be begun. The flaps so formed are most conveniently held out of the way by an assistant with a pair of blunt hooks during the division of the bone. This must be sawn

Fig. 39.—Amputation of Right Thumb and Metacarpal Bone by Transfixion. Cutting the Palmar Flap.

obliquely, as in the case of the index finger. As in the index finger, the head should be left in the hand of a working man.

The after-treatment of these cases is extremely simple. The hand should be put upon a splint, the wound covered with some antiseptic dressing, and the ends of the fingers, with small pieces of lint interposed, tied together by means of a tape, care being taken, however, that they do not overlap. The shaft of the metacarpal bone that is left will gradually atrophy, and thus a very shapely hand will eventually be left (Figs. 36, 37, 38).

In disease or injury of the **Thumb** as little as possible should be removed by amputation ; for, if even but a very short stump of the metacarpal bone be left, it will serve as a useful opponent for the other fingers.

Amputation of the Thumb with its Metacarpal Bone is an operation which can very rarely be required. In cases of injury the Surgeon must use all his ingenuity to save even the smallest part of the bone, or if any doubt exists as to how much can be saved, the hand should be dressed antiseptically and left to nature, a stump being fashioned later on, after the dead parts have separated. By this means more can be saved in many cases than at first

seemed possible. In cases of disease of the metacarpal bone, excision of the bone should be preferred to complete amputation. Should the operation, however, be necessary, it may be done either by the *flap* or the *oval* method. The *flap* method is thus performed: The Surgeon stands with the back of the patient's hand towards himself, the limb being midway between pronation and supination, and he holds the thumb by the ungual phalanx. In operating on the *right* side he commences the incision immediately above, and a little to the palmar aspect of the tubercle to be felt at the outer side of the base of the metacarpal bone; from this point he carries a curved incision passing immediately below the metacarpo-phalangeal articulation on the dorsal aspect to the middle of the web between the thumb and index finger. While making this incision, the operator's hands are necessarily crossed, but this causes no inconvenience if he leans slightly over the patient's hand. Still holding the thumb, the operator now supinates the hand, and passes the knife by transfixion from the lower end of the first incision, in the web, to the point at which it was commenced, taking care to keep the blade close to the palmar aspect of the metacarpal bone (Fig. 39). The palmar flap is now cut, the knife being brought out in a line exactly corresponding to the incision which has been made on the dorsal aspect. During this part of the operation the thumb must be slightly adducted, and care must be taken not to haggle over the sesamoid bones, and at the same time not to notch the flap by turning the edge of the knife too much towards the palm in trying to avoid them. The palmar flap being cut, the Surgeon gives the thumb to an assistant while he dissects back the dorsal flap by a few touches of the knife. This being accomplished, he again takes the thumb, and forcibly abducts it, while he carefully passes the knife down towards the joint, along the palmar aspect of the metacarpal bone, separating the remaining attachments of the short muscles, and finally opening the articulation from its inner and palmar aspect. During this part of the operation the knife must be kept turned towards the bone, so as to avoid wounding the radial artery as it passes between the heads of the first dorsal interosseous muscle. As soon as the joint is opened the thumb should be separated by twisting it round while the edge of the knife is sawn gently against the base of the bone. The radial artery, as it winds below the styloid process, is easily wounded at this stage of the operation, unless the knife is kept constantly in contact with the bone. In operating on the *left* side exactly the same course is followed, except that it is not necessary for the Surgeon to cross his hands, and the first incision is made from the web to the base of the bone, and the transfixion from that point to the web.

Fig. 40.—Result of Amputation of Thumb and its Metacarpal Bone.

In the *oval* method of amputating, which is, as a rule, to be preferred, the incision is commenced opposite the outer tubercle at the base of the metacarpal bone, and carried along the outer border of the bone to within about half-an-inch of the head. From this point an oval incision is carried round, passing in front over the metacarpo-phalangeal articulation, thus completing a racket-shaped incision. The flaps are then turned back, care being taken, if possible, not to open the metacarpo-phalangeal articulation, and the operation is con-

cluded in the same way as in the transfixion method. Should the metacarpo-phalangeal articulation be opened, the phalanges must be removed, and the head of the metacarpal bone seized in a pair of lion-forceps, after which no difficulty will be found in finishing the operation. Fig. 40 shows the hand after amputation of the thumb and its metacarpal bone.

Fig. 41.—Hand after Amputation of Metacarpal Bones and First Two Fingers.

The **Metacarpal Bones**, with or without the fingers supported by them, occasionally require removal for disease or injury. For these operations, which are not of a very regular kind, it is difficult to lay down definite rules; in performing them, care should be taken to make flaps of sufficient size, and to avoid cutting into the palm if possible. It is well not to disarticulate the lower end of the bones, so as to open the wrist-joint, but rather to cut them off a little above this with bone-forceps or a metacarpal saw. In injuries from the explosion of powder-flasks or gun-barrels, when the hand is much shattered, it is of great consequence to avoid cutting up the palm to too great an extent; and it is well in these cases if possible to save a finger, which will be of more use to the patient than any artificial limb, however ingeniously constructed (Figs. 41 and 42). When

Fig. 42.—Hand after removal of Metacarpal Bones and Three Fingers, leaving Thumb and Little Finger.

Fig. 43.—Amputation of the Wrist by Teale's method.

only one finger is left, as the index or little finger, with the thumb, in cases of partial amputation of the hand after injury or for disease, the digit that remains not only becomes more mobile than formerly, but is increased in size and stronger, so that its utility is materially augmented. In all cases in which the extent of the injury is doubtful, the hand may be rendered

thoroughly aseptic by immersion in a bath of carbolic acid lotion (1 in 20), or some other efficient antiseptic solution, for a few minutes, and then dressed with some antiseptic dressing for a week or more, and a secondary amputation performed when the limits of the injury are clearly defined. If the prevention of decomposition is successfully accomplished, no constitutional or local trouble is caused by this mode of treatment, and the amount saved is often more than was at first expected.

The mortality after amputation of the fingers and metacarpal bones is very trifling. Should death occur after such a slight operation, it would probably be by the occurrence of some infective disease, such as erysipelas, pyæmia, or tetanus.

An excellent stump may in some cases be obtained by amputating **between the carpus and metacarpus.** All the movements of the wrist-joint remaining perfect, a very useful artificial hand can be easily applied. The covering may be taken chiefly from the dorsal or palmar surface, the latter being preferable when possible.

Fig. 44.—Amputation at the Wrist by Long Palmar Flap.

Amputation at the Wrist is not very often required. In performing disarticulation at this joint, its shape, with the convexity looking upwards, must be borne in mind. The operation may be performed in three ways, the chief flap being cut either from the dorsal or palmar surface or from the radial side of the hand. In the first case, it is best performed by *Teale's method* (Fig. 43). A perfectly square flap, whose four sides are each equal in length to half the circumference of the limb at the level of the wrist-joint, is raised from the back of the hand. It must consist of skin and fat only, the extensor tendons being left on the hand. A short palmar flap, also composed of skin and fat only, and equal in length to one-quarter of the dorsal flap, is next raised. The extensor tendons may now be divided at the level of the wrist, and the joint opened and disarticulated. Lastly, both flaps being held well back, the flexor tendons are smoothly divided with a single sweep of the knife. The flaps must be brought accurately together in the way described on p. 68, Fig. 26. By this method the dorsal flap is somewhat long and thin, and is consequently liable to slough unless it be very carefully raised, care being taken not to turn the edge of the knife to the flap, but to keep it constantly directed towards the parts to be removed.

In amputation by the *long palmar flap*, the operation has been performed, either by cutting the flap from within outwards after opening the wrist-joint, or by shaping the flap from the palm first and disarticulating afterwards. The former method is objectionable, as the prominence of the pisiform bone and the hook of the unciform on the inner side render its performance

extremely difficult. In the latter method (Fig. 44) a large flap, almost square in shape, but having its angles rounded off, is marked out in the palm by an incision commencing at one styloid process and terminating at the other. The flap should extend to within one finger's breadth of the transverse fold in the palm opposite the heads of the metacarpal bones, and should include everything down to the flexor tendons. The flap is raised without difficulty till the ridge of the trapezium and the hook of the unciform are met with. At this point great care must be taken to keep the edge of the knife turned towards the bones, while firm traction is exerted on the flap. If this be done it will usually be found that the anterior annular ligament and median nerve have been raised in the flap. When the palmar flap has been raised, a curved incision is made across the back of the wrist, with its convexity downwards, connecting the two extremities of the previous incision and marking out a flap about one inch in length. The wrist being forcibly flexed, the joint is now opened, and the ligaments divided. The hand is attached now only by the flexor tendons, which may be divided by a single sweep of the knife—*the palmar flap being carefully held out of the way*. The palmar flap will be found usually to contain the median and ulnar nerves and the superficial palmar arch, with portions of the muscles of the thumb and little finger. It is better to cut out a small piece of each nerve where it is exposed at the base of the flap, as the trunks might be a source of pain if pressed against the ends of the bones, and the branches supplying the palm of the hand arise at a higher level.

The most common error in performing this operation, and one which must be carefully guarded against, is commencing the incision for the palmar flap too much towards the palmar aspect of the wrist, instead of starting from the apices of the styloid processes. The base of the flap may thus be left very thin and narrow. In the after treatment it is better to place the stump supinated on a pillow above the patient's head, so that it shall drain better, and the flap may have less tendency to displacement.

Of these two methods amputation by the palmar flap is the better, and should always be adopted when the condition of the soft parts permits of it. If it is not possible to get sufficient covering from the palm, a good stump may sometimes be made by taking the flaps equally from the dorsal and palmar surfaces.

Amputation by the *external flap* (Dubrueil's method) is done by an incision commencing on the dorsal aspect of the wrist at the junction of the outer with the middle third and a little below the line of the articulation. The knife is carried downwards towards the cleft between the thumb and fore-finger till it reaches a point opposite the lower third of the metacarpal bone of the thumb, and then outwards across the bone to the inner side of the thenar eminence, which is followed upwards till the incision terminates on the palmar aspect, at a point exactly opposite that at which it commenced on the dorsum. The angles of the flap should be slightly rounded off in marking it out. The flap is then raised with as much of the short muscles of the thumb as possible. A second incision is then carried round the inner side of the wrist, half an inch below the styloid process of the ulna. The joint is then opened and disarticulation completed. The external flap is then brought inwards over the lower ends of the bones. This method is said to give a very good result. In all methods the end of the stump may be made more level by removing the extremities of the styloid processes with a fine saw.

In **Amputation of the Forearm** as long a stump should be left as possible, so as to give the patient more power over an artificial limb. The operation may be done by equal dorsal and palmar flaps. In a muscular limb each flap must be well rounded and equal in length to the antero-posterior diameter of the limb at the point at which the bones are sawn, as the palmar flap especially has a great tendency to retract. In amputating the right forearm, the Surgeon stands above the arm, so as to have his left hand to the dorsal flap, which he will have to raise by dissection. The hand being pronated, the incision for the dorsal flap is commenced at the palmar aspect of the radius, is carried forward for the necessary distance parallel to this bone, and then across the back of the arm in a slightly curved line, until it reaches the palmar aspect of the ulna; it then passes along this until it reaches a point opposite to that at which it has commenced, and the flap thus made is dissected back. Care must be taken that this flap is wide enough at its free extremity: it should in fact be a rectangular flap with its corners rounded off. The palmar flap is next made by transfixion (Fig. 45). As soon as it is cut, the bones are cleared by a couple of sweeps of the knife, and the interosseous membrane is divided; the bones, being of nearly equal size, are then sawn together. The vessels are cut long and will be found on each side of the palmar flap at the free end. In operating on the left side of the body, the Surgeon stands below the arm, with his left hand, as before, to the flaps, and the incision is commenced from the ulnar side. This is the easiest, but by no means the best method of amputating the forearm, for when the palmar flap is cut by transfixion considerable inconvenience is caused by the protrusion of the mass of tendons and muscles included in it. To avoid this, both flaps may be raised by dissection. It is advisable to make the dorsal flap longer than the palmar, so that the line of the cicatrix may fall well away from the ends of the bones. The operation may be thus performed (Fig. 46). The Surgeon, standing so as to take the flaps in his left hand, and holding the arm with its dorsal surface upwards, enters the knife at the palmar edge of the bone furthest from him. He then marks out a flap from the dorsal surface, equal in length to two-thirds of the antero-posterior diameter of the limb at the point where it is intended to saw the bones. The flap must be sufficiently broad, and rounded at its corners. After raising this, taking only the skin and fat, a flap similar in shape, but half the length, is raised from the palmar surface. This flap must be marked out by drawing the knife under the limb while it is still in the pronated position, but the forearm must be supinated while it is being dissected up. The knife is now firmly swept round the limb at the level of the angle of the flaps (Fig. 46), so as to divide the muscles

Fig. 45.—Amputation of the Forearm. Transfixion of the Anterior Flap.

circularly at this point. The soft parts are now to be retracted from the bones by a process of careful dissection, or by raising the periosteum with an elevator (p. 71), for a distance equal to half the diameter of the limb at the point where the bones are to be sawn, and the bones sawn at this point. The result is, that the bones are buried in the muscles, and over all lie the light skin flaps, free from any tension or tendency to displacement. There will be a dependent opening for the exit of discharges, and, when healed, the cicatrix will be well to the palmar aspect of the bones, and consequently free from pressure. It may be found, in retracting the muscles from the bones, that the anterior interosseous artery has been cut in more than one place ; this may cause some trouble in securing it. Great care should therefore be taken to avoid the accident, by keeping the edge of the knife constantly turned towards the parts to be removed, or by using the periosteal elevator. If the median and ulnar nerves are seen to be cut somewhat long, they should be pulled out with

Fig. 46.—Amputation of the Forearm by Skin Flaps.

forceps, and cut short, so as to avoid if possible their implication in the cicatrix near the end of the bone.

Amputation at the Elbow-joint is not very frequently performed, as the cases in which it is practicable are not common. In all cases of disease of the elbow-joint in which excision is not advisable or has failed, the lower end of the humerus must be removed, and it is only in a few cases of sarcoma and injury that the limb can be taken off at the joint. When practicable, however, amputation at the joint should be performed. The operation is easy and the long stump left is very useful. Amputation through the elbow-joint has been done by numerous methods, of which the most common have been the long anterior flap and the circular. In the operation by the *long anterior flap* the arm is held, by the assistant, fully extended and supinated. The Surgeon stands with his left hand to the flaps. In operating on the left arm the incision is commenced about one inch below the point of the inner condyle, and carried straight down the inner side of the forearm for a distance equal to a diameter and a half of the limb at the elbow ; it is then carried across the front of the forearm to the outer side and upwards to a point corresponding to that at which it commenced. On the right side the direction of the incision is reversed. The flap should be broad and nearly

rectangular in form, its angles being rounded off. The flap so marked out is then raised, including only skin and fat for a short distance, and then gradually being deepened, dividing the muscles of the forearm, the brachialis anticus and the tendon of the biceps till, at its base, it reaches the front of the joint. The knife is then swept round behind the forearm, marking out a flap about half the length of that in front. This is carefully raised from over the olecranon, care being taken not to perforate the skin. Disarticulation is then performed, the joint being opened at the radio-humeral articulation.

If the condition of the soft parts will not allow of this method, a *simple circular* amputation may be performed. It is better to make the circular sweep a little obliquely, leaving the covering slightly longer on the outer side to allow for the greater retraction caused by the supinator longus. The skin and

Fig. 47.—Amputation of the Arm. Clearing the Bone.

fat are then turned up in the usual way, and the remaining soft parts divided circularly at the level of the articulation. Good stumps have also been made by flaps taken from the inner or outer side of the forearm, according to the circumstances of the case, by equal lateral flaps, and by various oval incisions, but the two methods above mentioned will be found most generally useful.

Amputation of the Arm may be performed by the pure circular (p. 59), by the modified circular (p. 67), or by the flap operation (p. 61). The modified circular is the best, but any method will give good results provided sufficient covering be made. The covering should, as a rule, be taken equally from the two sides, as this enables the operator to saw the bone at the lowest possible point, and the utility of the stump will to a great extent depend on its length. The *flap operation* may be performed by lateral flaps made by transfixion from before backwards; the bone is then well cleared by a couple of sweeps of the knife, and sawn across. In clearing the bone, care must be taken fairly to

divide the musculo-spiral nerve by a firm sweep of the knife round the back of the bone (Fig. 47), if the amputation be performed in that part of the arm where this nerve winds round the humerus. The operation is also frequently performed by antero-posterior flaps. In this method the anterior flap includes the biceps and brachialis anticus, and the posterior contains the triceps. The brachial artery and the median nerve may be left in either flap as may seem most convenient to the operator, but care must be taken that the artery is not pierced during transfixion. The choice of the operation depends somewhat upon the condition of the limb; if it be muscular, the circular or modified circular will give the best results.

Amputation at the Shoulder-joint may be performed by the flap or the oval method. If it be required for injury the oval is preferable, but the flap method may also be employed. If it be for a tumour of the upper end of the bone the flap method by dissection will be found the best operation.

Fig. 48.—Amputation at the Shoulder-joint by Transfixion.

Hæmorrhage during the operation must be prevented by the means described at pages 47 and 50.

In operating by *transfixion*, a long narrow-bladed knife should be used. One assistant must have charge of the limb; another should raise the flap; and a third must follow the knife as it cuts behind the humerus, and grasp the inner flap with the axillary artery, so as to prevent hæmorrhage from this vessel. An assistant holding the arm away from the body so as to relax the deltoid, the knife, instead of being entered by a puncture, should make a small cut, about an inch in length, to the point at which transfixion is to be made, so as to prevent that jagging of the integuments by the heel of the instrument which would otherwise occur. If the operation be on the *right* side, the Surgeon stands before the patient, and the point of the knife should

be entered midway between the acromion and the coracoid process (Fig. 48); and being carried directly across the joint and capsule, should pass out well behind the acromion, and about an inch below the spine of the scapula. If on the *left* side, the Surgeon stands behind, and the point of the knife must be entered well behind the acromion below the spine of the scapula, at the posterior border of the axilla, carried across to the anterior aspect of the joint, and brought out on the outer side of the coracoid process. In either case, the large flap containing the deltoid muscle must then be cut by a sweep of the knife downwards, and raised by the assistant. The heel of the knife is now to be laid on the head of the bone, the capsule of the joint cut across, and the attachments of the muscles to the tuberosities divided. In order to facilitate this part of the operation, it is generally recommended that the arm should

Fig. 49.—Amputation at the Shoulder-joint. Opening the Capsule, and making Inner Flap.

be carried forcibly inwards across the chest. This may readily be done in the dissecting-room, or in actual practice when the limb is removed for disease of the humerus, the bone being entire; but in the case of comminuted fracture high up, the lever-like action of the bone cannot be put in force, and it is sometimes no easy matter to detach the head from the glenoid cavity. In order to do this, I have found it necessary, after opening the capsule, to seize the upper fragment and draw it forcibly downwards and outwards by inserting the fingers between the head and the glenoid cavity, in order to divide the muscles inserted into it. After the head of the bone has been turned out, the knife must be passed over it and carried down for a distance of about three inches close to the bone at its inner side (Fig. 49). The Surgeon then cuts across the soft parts, so as to form the inner flap.

While he is doing this, the assistant to whom this duty is entrusted, must follow the knife with his hands, grasping firmly the whole thickness of the inner flap, so as to compress the axillary artery (Fig. 50). The Surgeon should not finish cutting the flap until the assistant tells him that he holds the vessel firmly, and then he must be careful not to injure his assistant's fingers. The artery will be found to be cut long in the middle of the inner flap, and a few smaller branches may be required to be tied at its inner angle, and in the deltoid. The stump after it is healed will present the appearance shown in Fig. 52.

Unless the deltoid is well developed and well covered by subcutaneous fat, it is usually impossible to make a flap sufficiently wide to form an efficient covering by transfixion, and it must then be raised by dissection. The

Fig. 50.—Amputation at the Shoulder-joint. Holding Vessels in the Inner Flap.

line of the incision through the skin corresponds exactly with that just described. In operating on the right side, the Surgeon, standing below the shoulder, grasps the arm and carries it slightly over the trunk; he commences his incision well behind the acromion, and a short distance below the spine of the scapula, near the posterior fold of the axilla, carrying it downwards to the level of the insertion of the deltoid, and then across the outer side of the arm and upwards to a point a little external to the coracoid process. He thus follows the ordinary rule of cutting from his left hand to his right. On the left side the direction of the incision is reversed. The deltoid being dissected up, the joint is opened and the inner flap cut in the way above described. The deltoid flap may be raised by means of a short knife, should the operator prefer it; a broad bistoury is very convenient.

It must be changed for a long amputating knife after the joint is opened. This method of operating is specially adapted to cases of disease, and more particularly of tumours of the humerus, by which the soft parts are stretched and thinned.

Amputation by *antero-posterior flaps*, or Lisfranc's method, differs somewhat from the operation described above. It is thus performed :—If it is the left arm that is to be removed, the Surgeon grasps the limb as near the elbow as possible, and carries it outwards nearly to a right angle with the trunk. He then inserts the knife immediately in front of the posterior fold of the axilla, and passing it forwards so that it crosses the neck of the humerus at its posterior aspect immediately below the head, he makes the point emerge

Fig. 51.—Amputation at the Shoulder by Spence's Method.

just in front of the acromion. The knife is next brought out in such a way as to cut a neatly rounded flap some four inches or more in length from the posterior aspect of the limb. The arm is then crossed over the body, the joint opened, and the operation finished in the same way as that previously described. In operating on the right side the transfixion is made from a point immediately in front of the acromion to the posterior border of the axilla. The great rapidity with which this operation can be performed caused it to be highly appreciated before the invention of chloroform. It leaves the scar, however, in a more exposed situation than when a pure deltoid flap is raised.

Amputation at the Shoulder by the Oval Method.—In cases in which, from the state of the bone, the manipulations necessary for amputation by transfixion are impossible, the method originally invented by Larrey, or some modification

of it, must be adopted. Larrey commenced his operation by a vertical incision down to the bone, about two inches in length, starting from immediately below the acromion process. He then had the wound held open by an assistant, and passed the knife round the bone in front, inclining its point downwards so as to bring it out in the axilla at its lower border close to the insertion of the pectoralis major and in front of the axillary artery; a flap was then cut by transfixion, and the pectoralis major divided. The knife was then passed behind the bone and brought out in the axilla, posterior to the vessels, and a second flap cut including the insertion of the latissimus dorsi. These flaps were turned off the humerus by a few touches of the knife, and held on one side by an assistant while the joint was opened and disarticulated. The knife was then made to glide to the axillary side of the bone, and carried downwards with its edge towards the humerus till the assistant could grasp the artery: finally, the axillary vessels and the remaining skin were divided "at the level of the inferior angles of the two flaps." The result was a somewhat irregular oval amputation. In Larrey's Memoirs there is a figure showing that the flaps were cut by transfixion.

Fig. 52.—Stump after Amputation at the Shoulder-joint.

The most important modification of this method is that of Spence, which is specially adapted for gun-shot wounds of the upper end of the humerus. It consists in making the vertical incision further forwards, commencing it just external to and below the tip of the coracoid process, as in excision of the shoulder-joint, and carrying it downwards to the level of the insertion of the deltoid. The incision ought to expose the tendon of the long head of the biceps lying parallel to it. This may be turned on one side, and the joint opened and examined; and if from the state of the parts it be still considered necessary to amputate, the operation is completed by making an oval incision through the skin from the end of the original cut, taking care not to go so deeply on the inner side as to wound the vessels. The outer flap is then dissected up, so as to enable the Surgeon to get his knife internal to the head of the bone, between it and the axillary artery (Fig. 51). The assistant follows the knife with his hands, and grasps the vessels, and the operation is finished by dividing the axillary vessels, and the tissues left uncut at the inner side.

In this mode of operating much loss of blood may be saved by securing the vessels cut in the first part of the operation before opening the joint and proceeding to the division of the tissues at the inner side of the arm.

Of these operations, Spence's method is best whenever it is practicable. In tumours of the head of the bone the flap method by dissection is not suitable, as it is often necessary to remove a great part of the deltoid. In gun-shot or shell wounds the Surgeon is often obliged to do a more or less irregular operation owing to the injury to the soft parts. The transfixion methods are never to be recommended, unless for some reason rapidity of performance is desirable.

Amputation of the Arm with the Scapula and part of the Clavicle.—There are at least fourteen cases recorded, commencing with Cheselden's in 1737, in which recovery has taken place after the whole upper limb, together with the scapula and a greater or less part of the clavicle, has been torn away. Such cases suggested the possibility of removing the same parts for tumours invading the bones in that region, and in injuries in which sufficient covering is not left for an ordinary amputation at the shoulder.

The operation has now been performed probably in nearly one hundred cases. In 1887, Paul Berger, in a monograph on the subject, collected fifty-one cases chiefly from French literature. In 1890 Chavasse published a table of 44 cases, including one of his own, in which the operation had been performed for the removal of large tumours. The immediate mortality from the operation has been about 1 in 5 for cases of disease, and 1 in 3 for injury. It is impossible to lay down definite rules for its performance, as the lines of incision must necessarily vary with the size and situation of the tumour or the condition of the soft parts in an injury.

In all cases the first step is to expose the subclavian artery and vein, and to divide them between two ligatures. This is most easily done by removal of the middle third of the clavicle, by an incision reaching from the junction of the inner and middle thirds to near the outer end. The bone should be carefully cleaned with a periosteal elevator, and divided at the outer border of the sterno-mastoid, care being taken to protect the parts beneath while sawing. The clavicle is then raised and separated from the parts under it, and again divided close to the coraco-clavicular ligaments. The subclavius muscle and the fascia under it are then carefully divided, and the great vessels exposed and divided between two ligatures, the artery being tied before the vein to prevent congestion of the limb. If time is of great importance, the vessels may simply be clamped in forci-pressure forceps and tied after removal of the limb. The suprascapular artery and vein may also be divided and secured at this stage of the operation. The subsequent steps have been carried out in various ways, of which that recommended by P. Berger is probably the best. The patient is brought to the edge of the table so that the whole scapular region projects over it. The arm being abducted and the Surgeon standing between it and the body, an incision involving the skin and fat only is commenced in the middle of that already made for the removal of the portion of the clavicle and carried downwards and forwards, passing just external to the coracoid process, and then over the anterior part of the deltoid to the level of the lower border of the axilla. It is then curved inwards and backwards, so as to cross the inner side of the arm at the lower limit of the axilla, passing over the pectoralis major and latissimus close near their insertions. From the posterior border of the axilla it is continued downwards and backwards to the lower angle of the scapula. This antero-inferior flap is raised for a short distance, and the pectoralis major and minor are then divided, the latter close to its insertion. The scapula now falls away from the body, fully opening up the axilla, and the brachial plexus is now to be divided. The Surgeon now places himself outside the arm, which is carried across the chest, so as to expose the scapular region behind. The postero-superior flap is then cut by an incision starting from the outer end of that made for removal of the portion of the clavicle, and curved sharply downwards over the spine of the scapula, and continued to the point at which the anterior incision ended over the inferior angle.

divide the musculo-spiral nerve by a firm sweep of the knife round the back of the bone (Fig. 47), if the amputation be performed in that part of the arm where this nerve winds round the humerus. The operation is also frequently performed by antero-posterior flaps. In this method the anterior flap includes the biceps and brachialis anticus, and the posterior contains the triceps. The brachial artery and the median nerve may be left in either flap as may seem most convenient to the operator, but care must be taken that the artery is not pierced during transfixion. The choice of the operation depends somewhat upon the condition of the limb; if it be muscular, the circular or modified circular will give the best results.

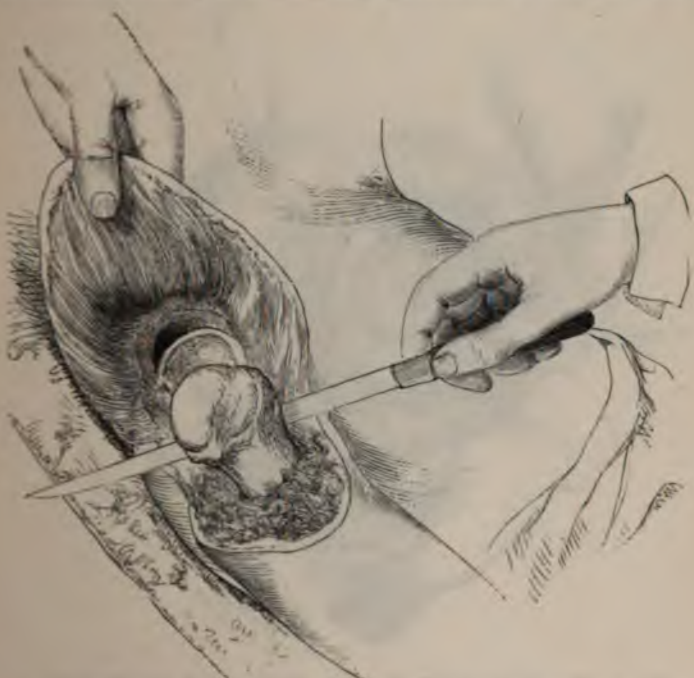
Amputation at the Shoulder-joint may be performed by the flap or the oval method. If it be required for injury the oval is preferable, but the flap method may also be employed. If it be for a tumour of the upper end of the bone the flap method by dissection will be found the best operation.

Fig. 48.—Amputation at the Shoulder-joint by Transfixion.

Hæmorrhage during the operation must be prevented by the means described at pages 47 and 50.

In operating by *transfixion*, a long narrow-bladed knife should be used. One assistant must have charge of the limb; another should raise the flap; and a third must follow the knife as it cuts behind the humerus, and grasp the inner flap with the axillary artery, so as to prevent hæmorrhage from this vessel. An assistant holding the arm away from the body so as to relax the deltoid, the knife, instead of being entered by a puncture, should make a small cut, about an inch in length, to the point at which transfixion is to be made, so as to prevent that jagging of the integuments by the heel of the instrument which would otherwise occur. If the operation be on the *right* side, the Surgeon stands before the patient, and the point of the knife should

be entered midway between the acromion and the coracoid process (Fig. 48); and being carried directly across the joint and capsule, should pass out well behind the acromion, and about an inch below the spine of the scapula. If on the *left* side, the Surgeon stands behind, and the point of the knife must be entered well behind the acromion below the spine of the scapula, at the posterior border of the axilla, carried across to the anterior aspect of the joint, and brought out on the outer side of the coracoid process. In either case, the large flap containing the deltoid muscle must then be cut by a sweep of the knife downwards, and raised by the assistant. The heel of the knife is now to be laid on the head of the bone, the capsule of the joint cut across, and the attachments of the muscles to the tuberosities divided. In order to facilitate this part of the operation, it is generally recommended that the arm should



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be carried forcibly inwards across the chest. This may readily be done in the dissecting-room, or in actual practice when the limb is removed for disease of the humerus, the bone being entire; but in the case of comminuted fracture high up, the lever-like action of the bone cannot be put in force, and it is sometimes no easy matter to detach the head from the glenoid cavity. In order to do this, I have found it necessary, after opening the capsule, to seize the upper fragment and draw it forcibly downwards and outwards by inserting the fingers between the head and the glenoid cavity, in order to divide the muscles inserted into it. After the head of the bone has been turned out, the knife must be passed over it and carried down for a distance of about three inches close to the bone at its inner side (Fig. 49). The Surgeon then cuts across the soft parts, so as to form the inner flap.

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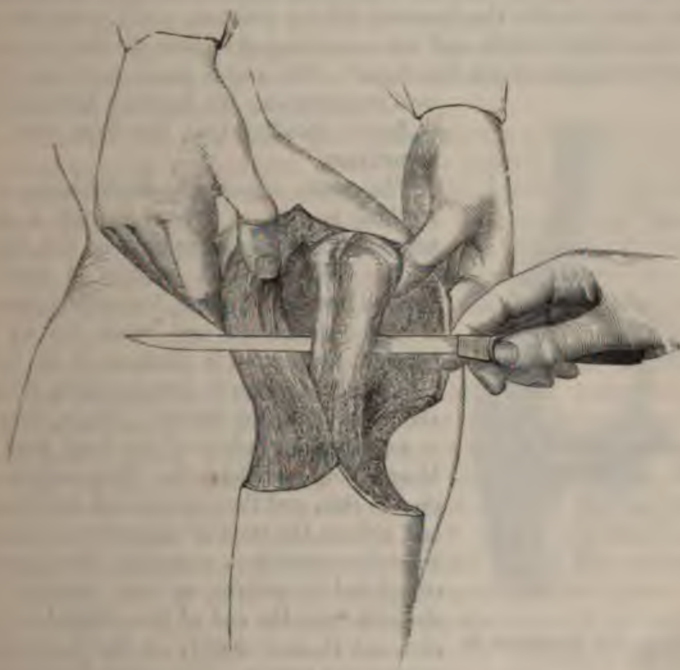

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of it, must be adopted. Larrey commenced his operation by a vertical incision down to the bone, about two inches in length, starting from immediately below the acromion process. He then had the wound held open by an assistant, and passed the knife round the bone in front, inclining its point downwards so as to bring it out in the axilla at its lower border close to the insertion of the pectoralis major and in front of the axillary artery; a flap was then cut by transfixion, and the pectoralis major divided. The knife was then passed behind the bone and brought out in the axilla, posterior to the vessels, and a second flap cut including the insertion of the latissimus dorsi. These flaps were turned off the humerus by a few touches of the knife, and held on one side by an assistant while the joint was opened and disarticulated. The knife was then made to glide to the axillary side of the bone, and carried downwards with its edge towards the humerus till the assistant could grasp the artery: finally, the axillary vessels and the remaining skin were divided "at the level of the inferior angles of the two flaps." The result was a somewhat irregular oval amputation. In Larrey's Memoirs there is a figure showing that the flaps were cut by transfixion.

Fig. 52.—Stump after Amputation at the Shoulder-joint.

The most important modification of this method is that of Spence, which is specially adapted for gun-shot wounds of the upper end of the humerus. It consists in making the vertical incision further forwards, commencing it just external to and below the tip of the coracoid process, as in excision of the shoulder-joint, and carrying it downwards to the level of the insertion of the deltoid. The incision ought to expose the tendon of the long head of the biceps lying parallel to it. This may be turned on one side, and the joint opened and examined; and if from the state of the parts it be still considered necessary to amputate, the operation is completed by making an oval incision through the skin from the end of the original cut, taking care not to go so deeply on the inner side as to wound the vessels. The outer flap is then dissected up, so as to enable the Surgeon to get his knife internal to the head of the bone, between it and the axillary artery (Fig. 51). The assistant follows the knife with his hands, and grasps the vessels, and the operation is finished by dividing the axillary vessels, and the tissues left uncut at the inner side.

In this mode of operating much loss of blood may be saved by securing the vessels cut in the first part of the operation before opening the joint and proceeding to the division of the tissues at the inner side of the arm.

Of these operations, Spence's method is best whenever it is practicable. In tumours of the head of the bone the flap method by dissection is not suitable, as it is often necessary to remove a great part of the deltoid. In gun-shot or shell wounds the Surgeon is often obliged to do a more or less irregular operation owing to the injury to the soft parts. The transfixion methods are never to be recommended, unless for some reason rapidity of performance is desirable.

Amputation of the Arm with the Scapula and part of the Clavicle.—There are at least fourteen cases recorded, commencing with Cheselden's in 1737, in which recovery has taken place after the whole upper limb, together with the scapula and a greater or less part of the clavicle, has been torn away. Such cases suggested the possibility of removing the same parts for tumours invading the bones in that region, and in injuries in which sufficient covering is not left for an ordinary amputation at the shoulder.

The operation has now been performed probably in nearly one hundred cases. In 1887, Paul Berger, in a monograph on the subject, collected fifty-one cases chiefly from French literature. In 1890 Chavasse published a table of 44 cases, including one of his own, in which the operation had been performed for the removal of large tumours. The immediate mortality from the operation has been about 1 in 5 for cases of disease, and 1 in 3 for injury. It is impossible to lay down definite rules for its performance, as the lines of incision must necessarily vary with the size and situation of the tumour or the condition of the soft parts in an injury.

In all cases the first step is to expose the subclavian artery and vein, and to divide them between two ligatures. This is most easily done by removal of the middle third of the clavicle, by an incision reaching from the junction of the inner and middle thirds to near the outer end. The bone should be carefully cleaned with a periosteal elevator, and divided at the outer border of the sterno-mastoid, care being taken to protect the parts beneath while sawing. The clavicle is then raised and separated from the parts under it, and again divided close to the coraco-clavicular ligaments. The subclavius muscle and the fascia under it are then carefully divided, and the great vessels exposed and divided between two ligatures, the artery being tied before the vein to prevent congestion of the limb. If time is of great importance, the vessels may simply be clamped in forci-pressure forceps and tied after removal of the limb. The suprascapular artery and vein may also be divided and secured at this stage of the operation. The subsequent steps have been carried out in various ways, of which that recommended by P. Berger is probably the best. The patient is brought to the edge of the table so that the whole scapular region projects over it. The arm being abducted and the Surgeon standing between it and the body, an incision involving the skin and fat only is commenced in the middle of that already made for the removal of the portion of the clavicle and carried downwards and forwards, passing just external to the coracoid process, and then over the anterior part of the deltoid to the level of the lower border of the axilla. It is then curved inwards and backwards, so as to cross the inner side of the arm at the lower limit of the axilla, passing over the pectoralis major and latissimus close near their insertions. From the posterior border of the axilla it is continued downwards and backwards to the lower angle of the scapula. This antero-inferior flap is raised for a short distance, and the pectoralis major and minor are then divided, the latter close to its insertion. The scapula now falls away from the body, fully opening up the axilla, and the brachial plexus is now to be divided. The Surgeon now places himself outside the arm, which is carried across the chest, so as to expose the scapular region behind. The postero-superior flap is then cut by an incision starting from the outer end of that made for removal of the portion of the clavicle, and curved sharply downwards over the spine of the scapula, and continued to the point at which the anterior incision ended over the inferior angle.

This flap, including skin and fat only, is raised sufficiently to expose the whole insertion of the trapezius, which must then be cut through. The limb is now allowed to fall below the table, so as to tilt forward the upper part of the scapula, and the remaining attachments are divided in the following order, the omo-hyoid, levator anguli scapulæ, rhomboid muscles and serratus magnus. As the levator is cut, an assistant must be prepared to seize the posterior scapular artery in forci-pressure forceps. The suprascapular, if not already tied, must also be seized as soon as cut. The bleeding is comparatively slight, and the operation is by no means difficult. It is important in the first stage to remove enough of the inner part of the clavicle, otherwise there may be some difficulty in securing the vein. If there is much trouble in exposing the vessels, the upper part of the anterior incision may be made, and the pectoralis major divided to bring them more easily into view.

General Results of Amputations of the Upper Limb.—Amputations of the upper extremity are, as a rule, extremely successful. Fatal shock rarely occurs except after operations at the shoulder-joint, and consequently with good hygienic surroundings and efficient antiseptic treatment almost every uncomplicated case of amputation in the upper limb should recover. This degree of success is in fact common at the present time. Where these advantages are not to be obtained, as for example in military surgery, the average death rate has been from 20 to 34 per cent. for the arm, and from 5 to 10 per cent. for the forearm.

Amputation at the shoulder-joint for injury, although necessarily more fatal, is very successful for so severe a procedure. At University College Hospital I have done the operation six times with one fatal result. In the English army in the Crimea, the mortality was only 35 per cent., and in the American Civil War it was 39·2 per cent. When the operation is performed for disease the results are more favourable.

AMPUTATIONS OF THE FOOT.—The **Phalanges of the Toes** seldom require amputation : when they do, they may be removed in the same way as the corresponding parts of the hand.

In removing a toe at the **Metatarso-phalangeal Articulation,** the oval method should always be practised, so that the sole of the foot may not be cut into (Fig. 53). The articulation is situated about the same distance above the web as the point of the toe is below it, and the incision must therefore be commenced about half an inch above this point (Fig. 53).

In removing any of the three middle toes, those on each side must be forcibly separated, and at the same time flexed as much as possible by pieces of bandage passed round them. The toes are too short to be held aside easily by the fingers of the assistant (Fig. 53). The forcible flexion of the neighbouring toes renders the articulation more superficial, and greatly facilitates the operation.

Amputation of the Great Toe is frequently required for injury and for destruction of the metatarso-phalangeal joint by extension of inflammation into it from a suppurating bunion. In such cases the head of the metatarsal bone should never be removed if it can possibly be saved, as it forms the anterior extremity of the arch of the foot on the inner side, and its loss tends to cause the foot to turn outwards. It is a common error to leave an insufficient covering for the head of the bone, the great size of which should always be borne in mind. To avoid this the operation should be performed by the racket-shaped incision, the oval part of which should not commence till the

knife has reached the middle of the proximal phalanx, and should pass, on the inner side, over the line of the articulation between the two phalanges. This amount of covering will not be found more than sufficient. In operations for injury it is not always possible to save so much, but all should be preserved that can be.

Anatomical Guides in the Foot.—In operating on the foot beyond the removal of separate toes, certain anatomical guiding points must be kept in mind some of which are usually perceptible even in cases of disease. Opposite the ankle-joint are the two malleoli. The tips of these, it must be remembered, are not opposite each other, the external being lower down and posterior, so that when, in Syme's operation, or in Pirogoff's, the direction is given to cut from the tip of the outer malleolus to the corresponding

Fig. 58.—Incision and Position of Joint in Amputation of a Toe.

point on the other side, it means to a point a little behind and below the inner malleolus.

The next point of importance on the inner side is the tubercle of the scaphoid, which forms a rounded prominence about half an inch in width. Its posterior border corresponds to the articulation between the scaphoid and the head of the astragalus and its anterior to that between the scaphoid and the internal cuneiform. The internal cuneiform is about one inch in length, so that at that distance from the anterior edge of the tubercle of the scaphoid will be found the articulation between the cuneiform and the metatarsal bone of the great toe, immediately in front of which is the well marked tubercle at the base of that bone. On the outer side, below and a little in front of the external malleolus, is the outer tubercle of the os calcis, which is often but indistinctly felt. About the middle of the foot the tubercle at the base of the fifth metatarsal bone forms a very marked prominence. Midway between the base of the fifth metatarsal bone and the tip of the external malleolus is the articulation between the cuboid and the os calcis; and this point is exactly opposite the tubercle of the scaphoid on the inner side.

The **Metatarsal Bone of the Great Toe** occasionally requires removal in whole or in part. The whole of the bone may be removed by one of two methods: 1, by a racket-shaped incision; 2, by the flap.

1. In *Amputation by the racket-shaped incision* the knife is entered on the dorsum of the foot about half an inch behind the tarsal end of the bone, and carried along the line of the bone to the level of the web between the first two toes; it is then swept round the great toe, forming an oval incision. On the outer side the knife must cut the skin at the point at which the web joins the great toe, and on the inner side the incision must correspond exactly to that on the outer. The oval part of the incision must not be commenced too soon; in fact, it must be nearly circular, or the covering will be found insufficient (Fig. 54). The soft parts are then dissected as cleanly as possible from the upper, inner, and under surfaces of the bones, taking care not to leave the sesamoid bones in the flap. The knife is next passed between the head of the metatarsal bone and the next toe with its edge turned towards the toe. It will now be found that the head of the bone can be separated to some extent from that of the second metatarsal bone by forcing the forefinger of the left

Fig. 54.—Amputation of the Great Toe and its Metatarsal Bone by the Racket-shaped Incision.

hand between them. If it is found difficult to hold the bone with the fingers the lion forceps may be used. The knife is now passed to the outer side of the bone with its edge turned towards the tarsus, as in Fig. 54, while the metatarsal bone is forcibly pulled inwards so as to put the external ligaments of the tarso-metatarsal joint on the stretch. The knife being carried upwards with its edge closely applied to the metatarsal bone will divide the tense ligaments as soon as it touches them, and the joint will thus easily be opened Then, by twisting the bone while the knife is closely applied to its base, the removal is completed. If the knife be not closely applied to the bone, and the ligaments put well on the stretch by forcibly pulling the toe inwards, it may enter the joint between the inner and middle cuneiform bones, and the latter bone may be removed. All danger of wounding the dorsal artery of the foot as it dips down between the two first metatarsal bones is avoided at the same time if the above directions are followed.

The operation may be greatly facilitated by commencing the incision at the ·· of the foot immediately behind the tuberosity at the base of the meta-

tarsal bone, one inch in front of the tuberosity of the scaphoid It is then carried towards the dorsum of the foot, following the line of the articulation; on reaching the dorsum it is curved sharply round into the line of the metatarsal bone, and the operation is finished as just described.

If the disease be limited to the anterior part, the shaft of the bone should be cut across with a fine saw.

This method has the advantage of leaving the sole uninjured.

2. The *flap amputation* is sufficiently explained by Fig. 55. It is far

Fig. 55.—Amputation of the Great Toe and its Metatarsal Bone by an Internal Flap

inferior to that by the racket-shaped incision, as it leaves an unnecessary scar in the sole of the foot.

The **Metatarsal Bone of the Little Toe** should be removed by a racket-shaped incision, so as to avoid wounding the sole. This is best done by entering the knife just behind the tubercle of the bone, carrying it forwards

Fig. 56.—Amputation of the Little Toe and its Metatarsal Bone by the Racket-shaped Incision.

and inwards, in the line of its articulation with the cuboid, to the centre of the fourth digital interspace, and thence forwards to the web of the toe; the knife is next carried round the plantar surface of this, the incision being continued obliquely into that which has been made on the dorsum of the foot (Fig. 56). The small flap thus formed is well dissected down, the

knife passed round the under surface of the bone, and the joint opened by the toe being forcibly drawn outwards, and its ligamentous connections divided.

The middle metatarsal bones, when diseased, do not admit of separate removal so as to leave a useful foot.

Amputation of the Metatarsus.—When the metatarsus and anterior part of the foot are diseased or injured so as to require removal, the amputation may be effected by one of two methods; viz., 1. By making a long flap from the sole and a short flap from the dorsum, and then sawing across the metatarsus as a whole above the seat of injury or disease; or, 2. By disarticulating the metatarsus from the tarsus.

The first operation—that of sawing through the metatarsus—is sometimes called Lisfranc's; but in reality it was practised and described by Hey long before Lisfranc's time. By "Hey's Amputation" is usually meant the disarticulation of the metatarsus from the tarsus, and the formation of a flap from the anterior part of the sole of the foot. But by reference to Hey's works ("Practical Observations," London, 1814, pp. 550, 553 and 554), it will be found that he describes three different operations, only one of which agrees with this. Thus it would appear that in his first case Hey *sawed across* the metatarsal bones after having made the flap. In the second case, he *dissected out* all the metatarsal bones, and then made a flap from the sole; and in the third, he first made the sole-flap, and then, having *dissected out* the four smaller metatarsal bones, *sawed* across the internal cuneiform; thus combining the two methods of cutting and sawing. In order to avoid any possibility of error, it is better to discard the terms Hey's and Lisfranc's operation, and to describe these proceedings as "amputation through the metatarsus," and the "tarso-metatarsal amputation."

The *whole of the Metatarsus* may be removed from the tarsus by making a curved incision in the sole of the foot, reaching to the roots of the toes, one horn of which commences at the tubercle of the fifth metatarsal bone, whilst the other terminates at that of the first, or one inch in front of the tubercle of the scaphoid. The flap thus marked out is carefully raised, taking skin and fat only for the first inch, and after that all the soft parts down to the bone. On the left side the direction of the incision is reversed. A small flap is then made on the dorsum of the foot and the articulations are exposed. These must then be opened with some care, as they are very irregular (Fig. 57); the second metatarsal bone being sunk between the inner and outer cuneiform bones, and the articulation of the fifth with the cuboid being very oblique. The line of the articulation is best found by forcing downwards the anterior part of the foot, while the point of the knife is drawn across the line of the joints. As the articulations are touched they gape slightly, but they are prevented from opening fully by the very strong interosseous ligament which passes between the outer side of the internal cuneiform and the base of the second metatarsal bone. This can be divided only by forcing the knife upwards between the two bones, taking care while so doing not to wound the base of the sole flap with the point. As soon as this ligament is divided, the whole line of joints readily breaks open, and disarticulation is performed without further difficulty. This operation is seldom actised, disease being rarely limited to the metatarsal bones, but usually licating the joints as well. Disarticulation from the tarsus, is, moreover,

troublesome, on account of the irregularity of the line of articulation ; hence it is better to saw through the metatarsus just in front of the tarsal articulations. A combination of these two procedures may sometimes be advantageously adopted ; as by disarticulation of the first metatarsal bone, and sawing the rest anterior to their articulations. In many cases the best result will be

Fig. 57.—B. Line of Hey's, or Tarso-Metatarsal Amputation. A. Line of Chopart's, or Medio-Tarsal Amputation.

Fig. 58.—Chopart's Operation. Flap formed before Disarticulation.

obtained by simply dissecting back the sole of the foot, clearing the bones, and sawing them across at a convenient line.

Amputation through the Tarsus may conveniently be performed by Chopart's, or the medio-tarsal, operation, which consists in disarticulation in the line between the os calcis and astragalus behind, and the cuboid and scaphoid in front (Fig. 57). This operation may be performed in two ways, either by first making the flap from the sole of the foot, and then disarticulating (Fig. 58) ; or, the joints having been cut through from the dorsum, the flap may afterwards be made (Fig. 60). In the latter plan, a smoother end will be obtained by transfixing the flap as in Figure 60, and cutting it in two parts from the middle. I prefer the first plan, as it enables the Surgeon to make a more correctly fashioned flap.

In operating on the *left* foot, the knife, a stout bistoury, should be entered immediately behind the tubercle of the scaphoid, and carried forwards to the head of the metatarsal bone of the great toe, then across the sole, and down the outer side of the foot, as far as midway between the tip of the external malleolus and the base of the fifth metatarsal bone. The two guiding points are exactly opposite each other, and if one is concealed by the swelling of the foot, the other can usually be found. On the *right* foot the line of incision is reversed, being commenced on the outer side and finished on the inner (Fig. 59, B). The flap should be made long, especially at the inner side, but well rounded at the angles. For the first inch it should consist of skin and fat only, the flexor tendons of the toes being left undivided; from this point to its base the whole of the soft parts must be dissected out from the concavity under the metatarsal bones. The sole flap having been raised, a convex incision is made over the dorsum, marking out a short flap about one inch in length, which must be raised by dissection, including all the soft parts except the tendons. The parts are well retracted, the extensor tendons divided, and the articulations opened by the Surgeon bearing firmly upon the anterior part of the foot, and lightly touching the ligamentous structures with the point of his bistoury. In this stage of the operation, care must be taken that the edge

Fig. 59.—A. Line of Incision for Amputation of Great Toe and Metatarsal Bone. B. Line for Chopart's Amputation. C. Line for Excision of the Os Calcis.

Fig. 60.—Chopart's Amputation. The Flap being cut after Disarticulation.

of the bistoury be not inclined too much backwards, lest it slip over the astragalus and open the ankle-joint; or too far forwards, lest it pass anterior to the scaphoid—between it and the cuneiform bones. In more than one

instance, I have found firm osseous ankylosis in the articulations, requiring the use of the saw for the separation of the anterior part of the foot. When this complication occurs, the tarsus should be treated as a whole, and sawn through, irrespective of articulations, behind the limits of the disease. The result of this operation is extremely favourable, the patient, by the aid of a properly constructed boot, being able to walk, and even dance, with very little appearance of lameness. In some cases the heel is drawn up by the muscles of the calf, and the end of the stump is made to point down in such a way that the patient is rendered lame by walking on the anterior sharp edge of the calcaneum. Verneuil states that he has observed, in a number of cases, that the heel is drawn up only in amputations for disease, and that it occurs really before the operation and not after. He has never noticed it in a primary amputation. This condition is best removed by division of the tendo Achillis.

Tripier's Modification of Chopart's Amputation.—In order to prevent the tilting downwards of the extremity of the stump Tripier has suggested sawing off the under part of the os calcis so as to present a flat surface for the patient to bear upon. In his operation the incision is commenced at the outer border of the tendo Achillis at the level of the tip of the external malleolus and carried downwards and forwards in a curve with the convexity downwards, passing about a finger's breadth above the base of the metatarsal bone of the fifth toe and ending at the inner side of the tendon of the extensor proprius hallucis over the articulation between the astragalus and the scaphoid. From this point the plantar incision is commenced, passing at first downwards over the scaphoid and internal cuneiform bones to the level of the articulation between that bone and the first metatarsal, then downwards and inwards in a curve to the sole of the foot and across to the base of the fifth metatarsal bone, from which it is carried upwards to join the first incision. (Fig. 63, T.) These incisions must extend to the bones. The flaps are then raised so as to expose the medio-tarsal joint at which disarticulation is performed. The soft parts are then raised from the under surface and sides of the os calcis with a periosteal elevator until a long narrow saw can be applied to the inner side of the bone immediately below the sustentaculum tali. (Fig. 62, T.) The lower and posterior part of the os calcis is then sawn off by a transverse cut so as to leave a flat level surface upon which the patient may rest. The angle left between the articular surface of the cuboid and the saw cut may be rounded off.

The operations just described are adapted to cases of disease, as it is important not to leave a part of the affected bones behind, and their removal is made more certain by operating through the lines of the articulations. In amputations for injury, however, it has been recommended by Mayor, of Lausanne, and others, to treat the foot as a whole, ignoring articulations. On this plan, a sufficient covering is turned up, encroaching on the foot as little as the nature of the injury will allow. When sufficient covering has been obtained, the saw is applied to the tarsus or metatarsus, as the case may be, saving as much of the foot as possible. There is no doubt that excellent results are obtained by this method, every half-inch of the foot that can be saved adding to its utility.

Sometimes the exact limits of the injury are difficult to ascertain with accuracy immediately after the accident. In such cases any loose or crushed fragments may be removed, and the foot placed for a quarter of an hour in a

bath of 1 in 20 carbolic acid lotion. It may then be dressed antiseptically, and the amputation deferred till the exact limits of the injury can be clearly ascertained. This line of practice was followed in two cases in University College Hospital. In one, the foot, which seemed at first hopelessly crushed, completely recovered; in the other it also recovered, with the exception of the great toe, which was amputated at the end of the second week.

The Subastragalar Amputation is seldom practised in this country, but seems to be more commonly adopted in France. In it the whole foot is removed except the astragalus. Several methods have been recommended for amputation in this situation, of which the following recommended by Nélaton is perhaps the simplest. In operating on the right foot, the incision is commenced about three-quarters of an inch below the external malleolus, in front of the insertion of the tendo Achillis, and carried, at first forwards

Fig. 61.—Subastragalar Amputation. *a*, Tendo Achillis; *b*, Interosseous Ligament.

for a short distance, and then in a curved direction downwards to the sole of the foot, so as to pass just behind the base of the fifth metatarsal bone. It then crosses the sole, and is brought up to the inner side of the foot, terminating about half an inch anterior to the tubercle of the scaphoid. The extremities of this line are then joined by a curved incision across the dorsum of the foot, reaching downwards to the lower edge of the scaphoid. The soft parts are then raised from the bone on the outer side, sufficiently to reach the tendo Achillis, which is to be divided (Fig. 61, *a*). On pushing the finger into the wound the upper surface of the os calcis, and the line of its articulation with the astragalus can now be felt. The point of the knife is next to be thrust into the articulation, and the interosseous ligament divided (Fig. 61, *b*), while the foot is wrenched forcibly inwards. Care must be taken not to injure the ligaments between the os calcis and the cuboid, or all power over the former bone would be lost. When the interosseous ligament

is divided, the astragalo-scaphoid articulation is to be opened, and finally, by twisting the foot so as to put the parts on the stretch, the soft parts at the inner side and the remainder of the heel flap are to be separated from the os calcis and the foot removed. In this amputation a good, long, useful stump results, which is said to possess greater elasticity from preserving the

Fig. 62.—S. Syme's Operation. T. Line of division of Os Calcis in Tripier's Operation.

ankle-joint; but the cases suited to it must be few, as it does not often happen that disease affects the calcaneum and the anterior range of tarsal bones, without the astragalus also being involved.

Disarticulation of the Foot at the Ankle-joint was first reduced by Syme to a regular operation. By its performance amputation of the leg may

Fig. 63.—T. Line of Incision for Tripier's Operation. S. Line of Incision for Syme's Operation. P. Line of Incision for Pirogoff's Operation.

often be avoided, the patient being left with an exceedingly useful stump, which, as its covering is taken from the heel, constitutes an excellent basis of support. In describing the operation on the right foot Syme's words as to the direction of the incision are: "The foot being held at a right angle to the leg, the point of the knife is introduced immediately below the malleolar projection of the fibula, rather nearer its posterior than anterior edge, and then

carried across the bone, slightly inclining backwards, to the inner side of the ankle, where it terminates at the point *exactly opposite* its commencement" (that is, a little below and behind the internal malleolus). On the left side the direction of the incision is reversed. "The extremities of the incision thus formed are then joined by another passing in front of the joint. The operator next proceeds to detach the flap from the bone" (Fig. 64). The object of carrying the incision so far back is, that the dissection of the flap may commence from the most prominent point of the plantar surface of the os calcis, that is to say, from the anterior part of the two tubercles of that bone. Every eighth of an inch in front of this point increases the difficulty of raising the flap. When the heel flap is turned back, the ankle-joint must

Fig. 64.—Syme's Amputation of the Foot. Clearing the Os Calcis.

Fig. 65.—Syme's Amputation of the Foot. Anterior Incision and Disarticulation.

be opened in front by cutting firmly across the line of the articulation, which is about half an inch above the tip of the inner malleolus, while the foot is forcibly extended. As soon as the joint opens sufficiently, the lateral ligaments are to be divided by cutting downwards between the malleoli and the lateral surfaces of the astragalus. The tendo Achillis is divided by pressing the foot forcibly downwards and cutting from before backwards, unless it has already been cut in turning back the heel flap. By twisting and dissecting at the same time the os calcis is completely separated from its soft attachments, and the foot removed (Fig. 65). The soft parts are then turned up from the lower ends of the tibia and fibula, the knife being kept close to the bones so as not to wound the vessels that lie immediately behind each malleolus. The whole of the parts of the tibia and fibula which enter into the ankle-joint are then sawn off, the arteries tied and the flap brought up. Care must be taken

that no button-hole apertures be made through the heel flap. This may easily be avoided when the soft structures are thickened and infiltrated by inflammatory products; but, if the operation be required for injury, great care is required in digging out the heel, the integuments of the posterior part of the os calcis being very thin and adherent to the bone. It is also of importance that the first incision should be (Figs. 62, 63) distinctly inclined backwards towards the heel, and not forwards into the sole of the foot. Unless this be done, a large cup-shaped flap will be left, in which blood and discharges may accumulate, and retard healing. If union takes place by the second intention, bagging of discharges in the flap must be prevented by uniform elastic pressure and bandaging. The tendency to sloughing occurs chiefly in primary amputations. It has frequently been stated that it is necessary, in order to ensure the vitality of the flap, to cut the posterior tibial artery "as long as possible," and it is this as much as anything that has led to the production of the large cup-shaped flaps which are so difficult to dissect off the os calcis, and which so often slough. An examination of the vascular

Fig. 66.—Line of Incision for Pirogoff's Operation—modified by Oblique Section of the Os Calcis.

supply will show that the posterior tibial artery may be cut close to the base of the flap, without interfering with the chief vessels supplying it. The distribution of vessels to the part is as follows. On the outer side, the peroneal artery, after giving off the anterior peroneal, is continued along the posterior aspect of the fibula to the outer side of the os calcis. On the inner side a branch of considerable size arises from the posterior tibial artery, about one inch above the ankle-joint, and passes down to the inner side of the os calcis, running behind the inner malleolus and accompanying the cutaneous nerve from the posterior tibial to the heel. There is thus a trunk on each side running down to the heel behind the malleolus, and these two communicate freely with each other, superficially over the cutaneous surface of the tendo Achillis, and deeply between the tendon and the ankle-joint; and they terminate by anastomosing by long loops on the under surface of the posterior part of the os calcis. It is upon these anastomosing loops that the vitality of the flap depends; and as they lie much nearer the bone than the skin it is evident that, unless the knife be kept hard upon the bone during

the whole dissection of the flap, they will be divided in large numbers, greatly endangering its vitality. In the operation as performed by Syme, the dissection of the flap is commenced from the most prominent part of the tubercles of the os calcis, and the knife can be kept in constant contact with the bone with the greatest ease. If, on the contrary, the incision extend far into the sole of the foot in front of the tubercles of the os calcis, it is almost impossible to dissect the flap back without the point of the knife being directed into its under surface and the vascular loops being divided.

This operation is a most useful one in all cases requiring removal of the

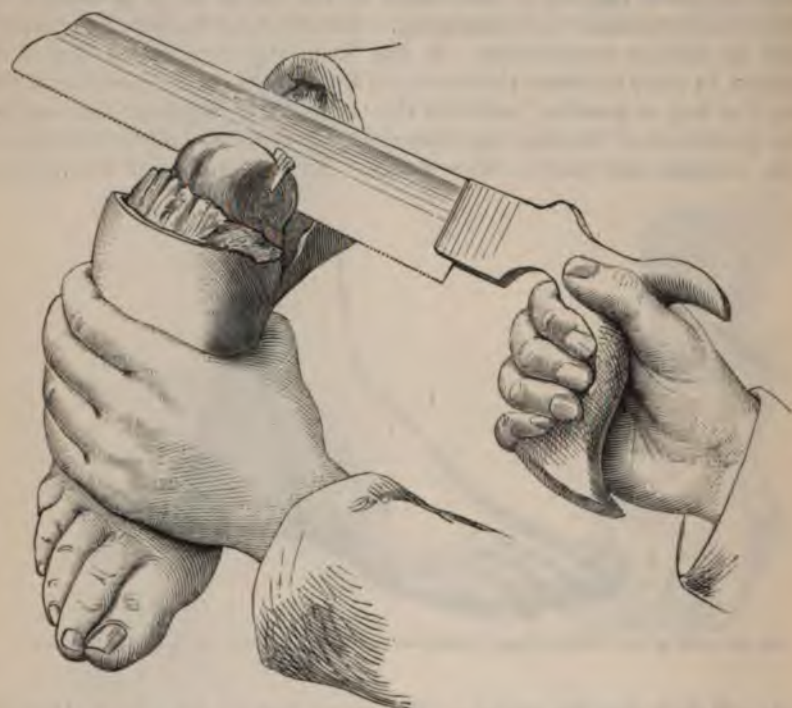

Fig. 67.—Pirogoff's Operation. Sawing the Os Calcis obliquely downwards and forwards.

whole foot. The mortality attending it is but small. The stump that is left admits of the whole weight of the body being borne upon it.

Various modifications of Syme's amputation may at times be practised with advantage, when the soft parts covering the heel are not in a condition to form a good basis of support. In these circumstances, the flaps may be fashioned on the side instead of from behind; and in this way I have more than once formed an excellent covering. These lateral flaps should not, however, be made in any case that admits of disarticulation at the ankle in the ordinary way, as they never afford so good a basis of support as the integuments of the heel.

Pirogoff's Amputation is characterised by the preservation of the posterior portion of the os calcis. In operating on the right side, an incision is carried across the sole of the foot from the tip of the external malleolus to the corre-

sponding point on the other side ; when operating on the left foot the direction of the incision is reversed. This incision should not be made directly transverse to the foot, but should incline forwards obliquely at an angle of about 45° to the line of the leg, the foot being held at right angles to the limb, so that the centre of the incision in the sole may (Fig. 66) reach a little beyond the anterior extremity of the os calcis. The knife should then be sunk in down to the bones, care being taken in crossing the sole of the foot that the blade is not turned at right angles to the sole, but is slanted obliquely backwards in the line of the incision from the malleolus. The ankle joint is then opened, as in Syme's operation, by an incision across the front. The foot is now forcibly extended to the greatest possible extent, a common amputation-saw or a jaw-saw is applied immediately behind the astragalus, and the bone cut obliquely downwards and forwards in the line of the incision in the soft parts, so that the saw should come out immediately behind the articulation of the os calcis with the cuboid (Fig. 67) ; the malleoli are then removed, together with a thin slice of the tibia, including the whole articular cartilage (Fig. 68).

Fig. 68.—Pirogoff's Amputation. Appearance of Parts after Removal of Malleoli.

Fig. 69.—Stump after Pirogoff's Amputation.

The opposed osseous surfaces must then be accurately adjusted, and the limb laid on the outer side, with the knee placed so as to take off the tension of the tendo Achillis. The advantages of the long oblique section of the os calcis over the shorter almost vertical cut originally made by Pirogoff are, as Busk pointed out, that a larger surface of the os calcis is brought into contact with the sawn end of the bones of the leg ; that the piece of bone left in the flap does not require to be tilted so much on its own axis, and that consequently the tendo Achillis is not put so much on the stretch ; and that the thick skin of the plantar surface of the heel still serves as the basis of support instead of the thin skin of the back of the heel, which is turned downwards in the other method. The alleged advantages of this operation over Syme's amputation consist in the stump being longer, to the extent of the thickness of the portion of the os calcis left in it, and being better adapted for pressure (Fig. 69) :

and in the diminished risk of sloughing of the flap, as its vascular communications are not much disturbed. These advantages are not, however, always real, and are in some degree counterbalanced by the liability to recurrence of the disease for which the operation may have been performed, in the portion of the os calcis left in the flap. When it is practised for injury, however, this objection does not hold good.

After either Syme's or Pirogoff's operation, patients can run; which they cannot do after amputation of the leg in any part.

In cases of caries of the tarsus requiring amputation, it occasionally happens that the Surgeon cannot determine with certainty whether the morbid condition is limited to the anterior range of tarsal bones, or extends so far backwards as seriously to implicate the astragalus and calcaneum; and he is consequently unable to decide whether the condition of the foot admits of removal by Chopart's operation, or requires disarticulation at the ankle-joint. In these circumstances all doubt will be cleared away by making an incision across the dorsum of the foot in the line of the astragalo-scaphoid and calcaneo-cuboid articulations; these are then opened, and the state of the bones is examined. If the astragalus and calcaneum be sound, or but slightly diseased on their anterior aspect, Chopart's operation may be done, and any carious bone left behind gouged away. If, on the contrary, these bones be found to be deeply implicated, the flap may be dissected back for about an inch, and disarticulation at the ankle-joint proceeded with.

Results.—The amputation of a toe, of a metatarsal bone, or even of a portion of the metatarsus, is but very seldom attended with fatal consequences. Should death occur, it must be the result of an accidental attack of tetanus, erysipelas, or pyæmia. Disarticulation at the ankle-joint, though necessarily somewhat more dangerous, is yet one of the most successful operations in Surgery, the mortality attending it being but very small.

The statistics of uncomplicated cases from the practice of Socin, Volkmann, and Max Schede, under antiseptic treatment, show 65 cases, with 2 deaths, 1 in a woman, aged 77, and 1 re-amputation. Those of Bruns, Bardeleben and Billroth, in the pre-antiseptic period, show 39 cases, with 10 deaths, 8 of which were from pyæmia. The highest mortality was from Pirogoff's operation, of which there were 13 cases, with 5 deaths, 4 from pyæmia and 1 from erysipelas.

Amputation of the Leg.—The selection of the line of amputation must depend upon the extent of the disease or injury, but, whenever practicable, the operation should be performed low down; the mortality diminishing in proportion as the limb is removed near to the ankle. Surgeons used formerly, even where the disease or injury was limited to the foot, to amputate immediately below the knee, or, as it was said, "at the seat of election," in all those cases in which the patient would be obliged to wear a common wooden pin, the long leg-stump being highly inconvenient when the patient rested on his bent knee; whereas, in those individuals who could afford the expense of a well-constructed artificial limb, the amputation, when practicable, was done in the lower part of the leg. But this difficulty has been removed by the introduction of a short wooden pin, in the socket of which the stump may be fixed in the extended position; and amputation in all admissible cases should consequently, even amongst the poorer classes, be done as low down as possible.

The number of arteries divided will depend upon the situation of the

amputation. Holden lays down as a general rule that in amputations one inch below the head of the fibula, only one main artery—the popliteal—is divided. At two inches two arteries—the anterior and posterior tibial—and at three inches three, are cut, the peroneal being divided in addition to the two tibials.

Flap Amputation of the Leg by Transfixion, which was at one time the operation usually performed in this country, is performed in the following way. The Surgeon stands with his left hand to the part to be removed, while the assistant, whose duty it is to retract the flaps, takes his stand opposite to the Surgeon. In the *right* limb, the point of the knife is entered at the posterior edge of the tibia, carried downwards for a distance of one inch and a half to two inches, then across the front of the leg to the posterior border of the

Fig. 70.—Amputation of the Right Leg. Transfixion of the Posterior Flap.

fibula, up which the incision is made to extend to a corresponding distance. In the *left* leg the same incision commences on the fibular side of the limb, and terminates on the tibial. The flap thus formed, which should be broad and well rounded, is next dissected up by a few touches of the point of the knife, and transfixion of the limb is made by passing the blade across behind the bones, from one angle of the incision to the other (Fig. 70), taking care not to pass the knife between the bones instead of behind them. The posterior flap is then formed by cutting obliquely downwards and backwards; it should be about three inches long. The bones are next cleared by a double sweep of the knife, and the interosseous soft parts divided by carrying the instrument in a figure-of-8 way between and round the bones. In doing this, special care must be taken not to direct the edge upwards, so as to split either of the tibial arteries, more particularly the anterior; for, as the vessel retracts above

the membrane, its ligature is no easy matter. If the amputation be performed just below the knee, it is possible that the popliteal trunk may be divided above its bifurcation, and thus only one artery may require ligature. In

Fig. 71.—Amputation of the Leg by the Long Posterior Flap. Sawing the Bones.

sawing the bones the fibula must be divided first, as otherwise it may be fractured above the line of amputation. It is better to commence sawing on the tibia till the saw has entered a short distance, and then by sinking or

Fig. 72.—Amputation of the Leg by Teale's Method.

raising the hand, according to the side on which the operation is being performed, the saw is brought to bear on the fibula, which is completely divided before the tibia is finished (Fig. 71). After the removal of the limb, the sharp anterior edge of the tibia must be sliced off obliquely, to lessen the risk of sloughing of the flap from pressure upon a sharp ridge of bone.

If the limb be very muscular, a large mass of the muscles of the calf will be left in the posterior flap; this will be a good deal in the way during treatment, as its weight tends to displace the flap. In some cases I have advantageously removed the greater part of the muscular mass thus left, leaving little more than a skin flap. The inconveniences arising from the long posterior flap are, however, so great that it is better as a rule to adopt some other method of amputation.

In the *lower third of the leg*, **Teale's operation** (Fig. 72) can be performed according to the rules laid down on p. 68. The size of the wound may, however, be diminished by making part of the covering by retracting the soft parts from the bones, instead of entirely by flaps as in Teale's method. In this modified plan of operating an anterior flap is made equal in length to the diameter of the limb at the point at which the bones are to be sawn; it should be almost rectangular in shape, merely having the angles rounded off. A very short posterior flap may be cut to meet this by carrying the knife behind the limb somewhat obliquely from one end of the first incision to the other. The soft parts are then retracted by the knife, or better by the periosteal elevator, thus saving the periosteum, and the bone is sawn an inch or more above the angle of the flaps. As in Teale's method, the flaps should contain all that can be taken from the bones, for in this situation they are somewhat liable to slough. The bones in this part of the leg occupy almost the whole thickness of the limb, and it is necessary, therefore, to make the anterior flap equal to the diameter in length, so that the scar may be behind them. If there is any difficulty in retracting the soft parts, Lister recommends that the incision should be carried, on the fibular side, as high as the point at which the bones are to be sawn, as this greatly facilitates their separation. In order to avoid unnecessary wounding of the anterior tibial artery, Teale recommends that the soft parts should be raised from the interosseous membrane with the thumb-nail.

In *the middle and upper thirds of the leg*, the bones lie more towards the anterior aspect of the limb, and consequently it is not necessary to cut so long an anterior flap in order that the cicatrix may be placed behind them. In these situations the anterior flap may be made equal in length to two-thirds of the diameter of the limb, and the posterior flap one-half the length of the anterior, the rest of the covering being made by retraction of the soft parts from the bones. The anterior flap should consist, at its lower edge, of skin and fat only, but it should be gradually deepened as it is raised, till at its base it contains almost all the muscle that can be obtained from the front of the limb (Fig. 73). In dissecting up the posterior flap, which should contain only skin and fat, the limb should be raised so that the Surgeon can more conveniently see what he is doing. Both flaps being held well out of the way, the muscles are next divided circularly, and the soft parts raised from the bones for a distance equal to at least one-third of the diameter of the limb. In doing this, care must be taken not again to wound the anterior tibial artery. Finally, the bones are sawn as high as possible. The sharp point of the tibia must be rounded off. In doing this, if the retraction of the soft parts have not already been done with a periosteal elevator, it is well carefully to raise the periosteum before applying the saw, as by so doing the tendency to necrosis is somewhat diminished, the periosteum not being torn away to a higher point than that at which the bone is actually sawn. In primary amputations the soft parts can

always be retracted without difficulty. In secondary amputations, when the parts are swollen, it may be necessary to make an incision upwards on one or both sides from the angle of union of the flaps towards the point at which the bones are to be sawn.

If from any cause there should not be sufficient skin available to form the long anterior flap, the **circular operation,** or the modification of it recommended by Liston, as described on p. 67, may be employed instead (see Fig. 24, p. 68). All these operations have the great advantage of getting rid of the heavy mass of the muscles of the calf, and that by the long anterior flap

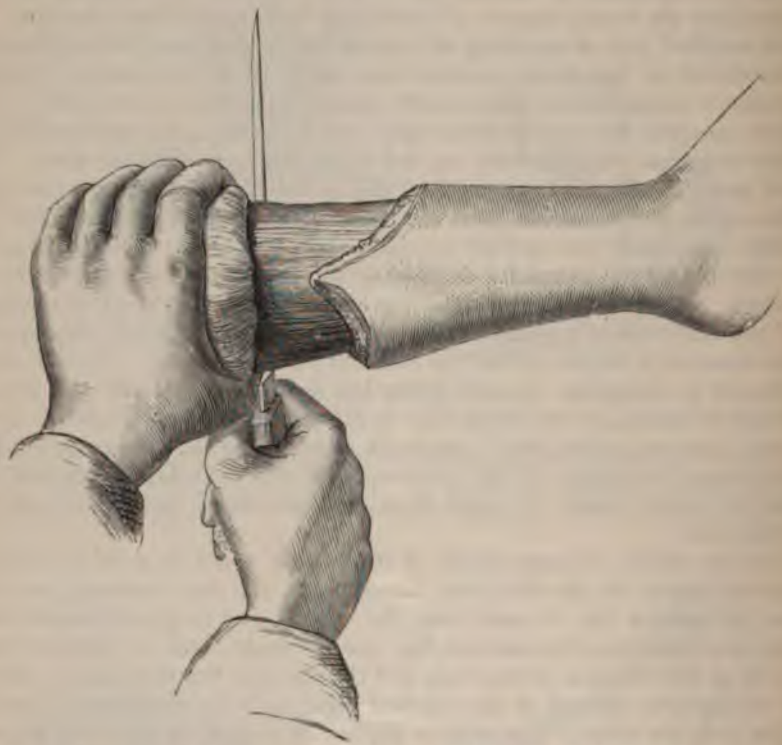

Fig. 73.—Amputation of the Leg by Long Anterior and Short Posterior Skin Flaps, with Circular Division of the Muscles.

secures in addition that the cicatrix shall be well behind the cut ends of the bones, and that there shall be a dependent opening for the exit of the discharges. The long anterior flap tends to keep itself in position by its own weight, and no strapping is required as in the amputation by the long posterior flap, and thus a great source of pain to the patient and of disturbance to the stump is avoided. There is also much less tendency to protrusion of the bone, as the weight of the flap is hardly sufficient to cause ulceration, if the end of the tibia has been carefully rounded.

Treves has obtained good results by the use of the **large external flap** recommended by Farabeuf for amputation at the seat of election. The flap is equal in length to the diameter of the limb at the point where the bones are

divided. The incision which marks out the flap begins in front at this same level, and ends behind at a point 1½ inch lower, whence an incision passes straight round the inner side of the limb. In dissecting up the flap the muscles must be cut through obliquely, and care taken that the anterior tibial artery is left uninjured on the deep surface of the flap.

Results.—The mortality after amputation of the leg was formerly very high, varying generally in different hospital reports from 50 to 30 per cent., the chief causes of death being pyæmia, gangrene of the stump and exhaustion. The death-rate was higher in secondary than in primary operations, and fell to 23·5 per cent. in cases in which the operation was performed for disease. So far as situation is concerned, as a general rule, the nearer the knee the greater the danger. The high death-rate formerly prevailing has now been much reduced. In the statistics published by Max Schede (p. 83), amongst the uncomplicated cases treated antiseptically, are 19 amputations for injury and 50 for disease, with only 1 death, and that was from erysipelas, in a patient who had previously suffered more than once from the disease. Amongst the uncomplicated cases treated by Bardeleben, Billroth, and Bruns, without antiseptics, were 28 for injury, with 15 deaths, and 87 for disease, with 25 deaths; 29 of the deaths were from pyæmia and 7 from septicæmia.

Amputation through the Knee-joint, originally recommended in the last century by Hoin, and reintroduced by Velpeau, Markoe, and Brinton, has long found favour in this country and in America.

Amputation through the knee-joint may be performed in three different ways: 1, with a long anterior and a short posterior flap; 2, with lateral flaps; 3, with a long posterior and a short anterior flap.

1. The operation by means of a **Long Anterior and Short Posterior Flap** is thus performed. A long square flap, rounded at the corners, is made by entering the point of a short broad-bladed amputating-knife towards the posterior part of one condyle, carrying the incision downwards in a straight line for four or five inches, then across the limb, and cutting upwards to a point on the opposite side corresponding to that of entry. The integuments and the patella are then dissected from the front of the joint (Fig. 74). The articulation is thus opened; the ligaments are then successively divided, the limb being forcibly bent; and a posterior flap is formed by cutting from behind forwards, or by dissecting down behind the bones and then cutting backwards. The flap should be about 2½ to 3 inches long. If made shorter than this, it is apt to retract up the back of the thigh. Indeed, in all cases there is a great tendency to this, even when the flap is of the length above given. The popliteal artery is divided, and, with the exception of the articular vessels, is the only one requiring ligature.

The management of the patella is an important question; some Surgeons advocating its removal and others its preservation. I think that it is decidedly better to leave it, as it forms an important protection to the end of the stump. If it be removed, the flap becomes so thinned as to incur danger of gangrene. I have practised the operation both ways, and have from my experience found it most advantageous to leave the patella. There is only one objection to this; and that is the chance of the patella being drawn up, as occasionally happens, upon the anterior part of the thigh. This is best prevented by cutting across the tendinous insertion of the quadriceps extensor during the operation.

The cartilage on the femur should be left untouched, as thus the cancellous structure is not opened, and one predisposing cause of pyæmia is avoided. The operation is not adapted to cases in which the joint is diseased ; in them it is better to amputate through the condyles.

In the after-treatment great trouble may arise from accumulation of the discharges in the synovial pouches. This can be prevented only by proper drainage and pressure. Before closing the wound, two long tubes must be put in, in such a way that their deep extremities lie in the extreme upper parts of the synovial pouches, and their lower ends at the angles of the wound. These tubes should not be touched till the third day ; after that they may be drawn out half an inch or more at each dressing, and the projecting piece cut off. They must on no account be completely removed in order to shorten them, as it would be impossible to replace them. Should pus form in the synovial pouches from failure of the drainage, it will be recognised by the swelling, redness and pain, with fluctuation. A free incision must be made into it as soon as the condition is recognised, or the pus may burst through the limits of the synovial pouch, and burrow up the thigh beneath the vasti. These precautions for drainage are necessary in all amputations in which the synovial pouches are opened.

Fig. 74.—Amputation through the Knee by Long Anterior Flap.

2. Stephen Smith disarticulates at the knee by **Lateral Flaps** in the following way : The incision is commenced in the middle line in front, about an inch below the tubercle of the tibia, and is carried downwards and backwards over the side of the leg, until it reaches the under surface, where it is directed upwards and towards the median line. When that point is reached, it is carried directly upwards to the centre of the popliteal space. A second incision begins at the same point as the first, and pursues a similar direction on the opposite side of the limb, the two incisions meeting in the median line behind. The flaps are next raised, and the soft parts dissected up circularly until the joint is opened, and the leg then removed. The inner flap should be rather the larger, because of the greater size of the inner condyle ; the patella

is left. After this amputation, the stump presents the appearance represented in Fig. 75. The operation, which is in reality rather a modified circular method than a true amputation by lateral flaps, gives the most excellent results. Bryant, who has recorded twenty cases, speaks highly of it, and recommends that in raising the flaps the knife should be kept close to the head of the tibia so as to divide the coronary ligaments, and thus leave the semilunar cartilages closely encircling the condyles of the femur. "By this means the upper part of the synovial capsule is held down firmly to the condyles of the femur, and thus all the soft parts are kept well in place." This mode of operating was also described in 1872 by Brinton.

3. The operation with the **Long Posterior and Short Anterior Flap** has the great disadvantage that the posterior flap has an almost uncontrollable

Fig. 75.—Amputation at the Knee by Lateral Flap.

tendency to retract, and it should never be undertaken when the covering can be obtained more extensively or entirely from the front. It may be readily performed in the following way. An incision is made directly across the knee-joint, just below the patella. The skin-flap thus formed is dissected back; and, the joint being opened above the patella, and the ligaments divided by a few touches of the knife, a long posterior flap is cut from the upper part of the calf of the leg, by passing the knife behind the tibia, and carrying it downwards for a suitable distance.

Amputation through the Condyles may be done in three different ways: 1, with a long anterior flap, including the patella or not; 2, by a modified circular method; 3, with a long posterior flap.

1. Carden, of Worcester, was the first to employ the method of amputation by the **long anterior flap** in this situation. He took away the patella and made no posterior flap; but subsequent operators have found that without a

and in the diminished risk of sloughing of the flap, as its vascular communications are not much disturbed. These advantages are not, however, always real, and are in some degree counterbalanced by the liability to recurrence of the disease for which the operation may have been performed, in the portion of the os calcis left in the flap. When it is practised for injury, however, this objection does not hold good.

After either Syme's or Pirogoff's operation, patients can run; which they cannot do after amputation of the leg in any part.

In cases of caries of the tarsus requiring amputation, it occasionally happens that the Surgeon cannot determine with certainty whether the morbid condition is limited to the anterior range of tarsal bones, or extends so far backwards as seriously to implicate the astragalus and calcaneum; and he is consequently unable to decide whether the condition of the foot admits of removal by Chopart's operation, or requires disarticulation at the ankle-joint. In these circumstances all doubt will be cleared away by making an incision across the dorsum of the foot in the line of the astragalo-scaphoid and calcaneo-cuboid articulations; these are then opened, and the state of the bones is examined. If the astragalus and calcaneum be sound, or but slightly diseased on their anterior aspect, Chopart's operation may be done, and any carious bone left behind gouged away. If, on the contrary, these bones be found to be deeply implicated, the flap may be dissected back for about an inch, and disarticulation at the ankle-joint proceeded with.

Results.—The amputation of a toe, of a metatarsal bone, or even of a portion of the metatarsus, is but very seldom attended with fatal consequences. Should death occur, it must be the result of an accidental attack of tetanus, erysipelas, or pyæmia. Disarticulation at the ankle-joint, though necessarily somewhat more dangerous, is yet one of the most successful operations in Surgery, the mortality attending it being but very small.

The statistics of uncomplicated cases from the practice of Socin, Volkmann, and Max Schede, under antiseptic treatment, show 65 cases, with 2 deaths, 1 in a woman, aged 77, and 1 re-amputation. Those of Bruns, Bardeleben and Billroth, in the pre-antiseptic period, show 39 cases, with 10 deaths, 8 of which were from pyæmia. The highest mortality was from Pirogoff's operation, of which there were 13 cases, with 5 deaths, 4 from pyæmia and 1 from erysipelas.

Amputation of the Leg.—The selection of the line of amputation must depend upon the extent of the disease or injury, but, whenever practicable, the operation should be performed low down: the mortality diminishing in proportion as the limb is removed near to the ankle. Surgeons used formerly, even where the disease or injury was limited to the foot, to amputate immediately below the knee, or, as it was said, "at the seat of election," in all those cases in which the patient would be obliged to wear a common wooden pin, the long leg-stump being highly inconvenient when the patient rested on his bent knee; whereas, in those individuals who could afford the expense of a well-constructed artificial limb, the amputation, when practicable, was done in the lower part of the leg. But this difficulty has been removed by the introduction of a short wooden pin, in the socket of which the stump may be fixed in the extended position; and amputation in all admissible cases should consequently, even amongst the poorer classes, be done as low down as possible.

The number of arteries divided will depend upon the situation of the

amputation. Holden lays down as a general rule that in amputations one inch below the head of the fibula, only one main artery—the popliteal—is divided. At two inches two arteries—the anterior and posterior tibial—and at three inches three, are cut, the peroneal being divided in addition to the two tibials.

Flap Amputation of the Leg by Transfixion, which was at one time the operation usually performed in this country, is performed in the following way. The Surgeon stands with his left hand to the part to be removed, while the assistant, whose duty it is to retract the flaps, takes his stand opposite to the Surgeon. In the *right* limb, the point of the knife is entered at the posterior edge of the tibia, carried downwards for a distance of one inch and a half to two inches, then across the front of the leg to the posterior border of the

Fig. 70.—Amputation of the Right Leg. Transfixion of the Posterior Flap.

fibula, up which the incision is made to extend to a corresponding distance. In the *left* leg the same incision commences on the fibular side of the limb, and terminates on the tibial. The flap thus formed, which should be broad and well rounded, is next dissected up by a few touches of the point of the knife, and transfixion of the limb is made by passing the blade across behind the bones, from one angle of the incision to the other (Fig. 70), taking care not to pass the knife between the bones instead of behind them. The posterior flap is then formed by cutting obliquely downwards and backwards; it should be about three inches long. The bones are next cleared by a double sweep of the knife, and the interosseous soft parts divided by carrying the instrument in a figure-of-8 way between and round the bones. In doing this, special care must be taken not to direct the edge upwards, so as to split either of the tibial arteries, more particularly the anterior; for, as the vessel retracts above

the membrane, its ligature is no easy matter. If the amputation be performed just below the knee, it is possible that the popliteal trunk may be divided above its bifurcation, and thus only one artery may require ligature. In

Fig. 71.—Amputation of the Leg by the Long Posterior Flap. Sawing the Bones.

sawing the bones the fibula must be divided first, as otherwise it may be fractured above the line of amputation. It is better to commence sawing on the tibia till the saw has entered a short distance, and then by sinking or

Fig. 72.—Amputation of the Leg by Teale's Method.

raising the hand, according to the side on which the operation is being performed, the saw is brought to bear on the fibula, which is completely divided before the tibia is finished (Fig. 71). After the removal of the limb, the sharp anterior edge of the tibia must be sliced off obliquely, to lessen the risk of sloughing of the flap from pressure upon a sharp ridge of bone.

If the limb be very muscular, a large mass of the muscles of the calf will be left in the posterior flap; this will be a good deal in the way during treatment, as its weight tends to displace the flap. In some cases I have advantageously removed the greater part of the muscular mass thus left, leaving little more than a skin flap. The inconveniences arising from the long posterior flap are, however, so great that it is better as a rule to adopt some other method of amputation.

In the *lower third of the leg*, **Teale's operation** (Fig. 72) can be performed according to the rules laid down on p. 68. The size of the wound may, however, be diminished by making part of the covering by retracting the soft parts from the bones, instead of entirely by flaps as in Teale's method. In this modified plan of operating an anterior flap is made equal in length to the diameter of the limb at the point at which the bones are to be sawn; it should be almost rectangular in shape, merely having the angles rounded off. A very short posterior flap may be cut to meet this by carrying the knife behind the limb somewhat obliquely from one end of the first incision to the other. The soft parts are then retracted by the knife, or better by the periosteal elevator, thus saving the periosteum, and the bone is sawn an inch or more above the angle of the flaps. As in Teale's method, the flaps should contain all that can be taken from the bones, for in this situation they are somewhat liable to slough. The bones in this part of the leg occupy almost the whole thickness of the limb, and it is necessary, therefore, to make the anterior flap equal to the diameter in length, so that the scar may be behind them. If there is any difficulty in retracting the soft parts, Lister recommends that the incision should be carried, on the fibular side, as high as the point at which the bones are to be sawn, as this greatly facilitates their separation. In order to avoid unnecessary wounding of the anterior tibial artery, Teale recommends that the soft parts should be raised from the interosseous membrane with the thumb-nail.

In *the middle and upper thirds of the leg*, the bones lie more towards the anterior aspect of the limb, and consequently it is not necessary to cut so long an anterior flap in order that the cicatrix may be placed behind them. In these situations the anterior flap may be made equal in length to two-thirds of the diameter of the limb, and the posterior flap one-half the length of the anterior, the rest of the covering being made by retraction of the soft parts from the bones. The anterior flap should consist, at its lower edge, of skin and fat only, but it should be gradually deepened as it is raised, till at its base it contains almost all the muscle that can be obtained from the front of the limb (Fig. 73). In dissecting up the posterior flap, which should contain only skin and fat, the limb should be raised so that the Surgeon can more conveniently see what he is doing. Both flaps being held well out of the way, the muscles are next divided circularly, and the soft parts raised from the bones for a distance equal to at least one-third of the diameter of the limb. In doing this, care must be taken not again to wound the anterior tibial artery. Finally, the bones are sawn as high as possible. The sharp point of the tibia must be rounded off. In doing this, if the retraction of the soft parts have not already been done with a periosteal elevator, it is well carefully to raise the periosteum before applying the saw, as by so doing the tendency to necrosis is somewhat diminished, the periosteum not being torn away to a higher point than that at which the bone is actually sawn. In primary amputations the soft parts can

always be retracted without difficulty. In secondary amputations, when the parts are swollen, it may be necessary to make an incision upwards on one or both sides from the angle of union of the flaps towards the point at which the bones are to be sawn.

If from any cause there should not be sufficient skin available to form the long anterior flap, the **circular operation,** or the modification of it recommended by Liston, as described on p. 67, may be employed instead (see Fig. 24, p. 68). All these operations have the great advantage of getting rid of the heavy mass of the muscles of the calf, and that by the long anterior flap

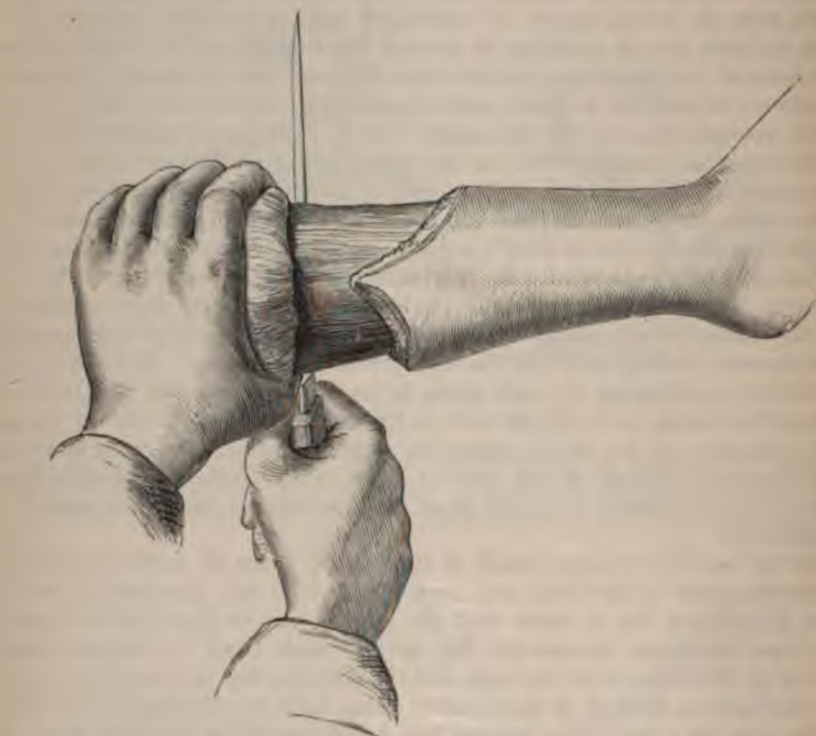

Fig. 73.—Amputation of the Leg by Long Anterior and Short Posterior Skin Flaps, with Circular Division of the Muscles.

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Results.—The mortality after amputation of the leg was formerly very high, varying generally in different hospital reports from 50 to 30 per cent., the chief causes of death being pyæmia, gangrene of the stump and exhaustion. The death-rate was higher in secondary than in primary operations, and fell to 23·5 per cent. in cases in which the operation was performed for disease. So far as situation is concerned, as a general rule, the nearer the knee the greater the danger. The high death-rate formerly prevailing has now been much reduced. In the statistics published by Max Schede (p. 83), amongst the uncomplicated cases treated antiseptically, are 19 amputations for injury and 50 for disease, with only 1 death, and that was from erysipelas, in a patient who had previously suffered more than once from the disease. Amongst the uncomplicated cases treated by Bardeleben, Billroth, and Bruns, without antiseptics, were 28 for injury, with 15 deaths, and 87 for disease, with 25 deaths; 29 of the deaths were from pyæmia and 7 from septicæmia.

AMPUTATION THROUGH THE KNEE-JOINT, originally recommended in the last century by Hoin, and reintroduced by Velpeau, Markoe, and Brinton, has long found favour in this country and in America.

Amputation through the knee-joint may be performed in three different ways: 1, with a long anterior and a short posterior flap; 2, with lateral flaps; 3, with a long posterior and a short anterior flap.

1. The operation by means of a **Long Anterior and Short Posterior Flap** is thus performed. A long square flap, rounded at the corners, is made by entering the point of a short broad-bladed amputating-knife towards the posterior part of one condyle, carrying the incision downwards in a straight line for four or five inches, then across the limb, and cutting upwards to a point on the opposite side corresponding to that of entry. The integuments and the patella are then dissected from the front of the joint (Fig. 74). The articulation is thus opened; the ligaments are then successively divided, the limb being forcibly bent; and a posterior flap is formed by cutting from behind forwards, or by dissecting down behind the bones and then cutting backwards. The flap should be about 2½ to 3 inches long. If made shorter than this, it is apt to retract up the back of the thigh. Indeed, in all cases there is a great tendency to this, even when the flap is of the length above given. The popliteal artery is divided, and, with the exception of the articular vessels, is the only one requiring ligature.

The management of the patella is an important question; some Surgeons advocating its removal and others its preservation. I think that it is decidedly better to leave it, as it forms an important protection to the end of the stump. If it be removed, the flap becomes so thinned as to incur danger of gangrene. I have practised the operation both ways, and have from my experience found it most advantageous to leave the patella. There is only one objection to this; and that is the chance of the patella being drawn up, as occasionally happens, upon the anterior part of the thigh. This is best prevented by cutting across the tendinous insertion of the quadriceps extensor during the operation.

The cartilage on the femur should be left untouched, as thus the cancellous structure is not opened, and one predisposing cause of pyæmia is avoided. The operation is not adapted to cases in which the joint is diseased; in them it is better to amputate through the condyles.

In the after-treatment great trouble may arise from accumulation of the discharges in the synovial pouches. This can be prevented only by proper drainage and pressure. Before closing the wound, two long tubes must be put in, in such a way that their deep extremities lie in the extreme upper parts of the synovial pouches, and their lower ends at the angles of the wound. These tubes should not be touched till the third day; after that they may be drawn out half an inch or more at each dressing, and the projecting piece cut off. They must on no account be completely removed in order to shorten them, as it would be impossible to replace them. Should pus form in the synovial pouches from failure of the drainage, it will be recognised by the swelling, redness and pain, with fluctuation. A free incision must be made into it as soon as the condition is recognised, or the pus may burst through the limits of the synovial pouch, and burrow up the thigh beneath the vasti. These precautions for drainage are necessary in all amputations in which the synovial pouches are opened.

Fig. 74.—Amputation through the Knee by Long Anterior Flap.

2. Stephen Smith disarticulates at the knee by **Lateral Flaps** in the following way: The incision is commenced in the middle line in front, about an inch below the tubercle of the tibia, and is carried downwards and backwards over the side of the leg, until it reaches the under surface, where it is directed upwards and towards the median line. When that point is reached, it is carried directly upwards to the centre of the popliteal space. A second incision begins at the same point as the first, and pursues a similar direction on the opposite side of the limb, the two incisions meeting in the median line behind. The flaps are next raised, and the soft parts dissected up circularly until the joint is opened, and the leg then removed. The inner flap should be the larger, because of the greater size of the inner condyle; the patella

is left. After this amputation, the stump presents the appearance represented in Fig. 75. The operation, which is in reality rather a modified circular method than a true amputation by lateral flaps, gives the most excellent results. Bryant, who has recorded twenty cases, speaks highly of it, and recommends that in raising the flaps the knife should be kept close to the head of the tibia so as to divide the coronary ligaments, and thus leave the semilunar cartilages closely encircling the condyles of the femur. "By this means the upper part of the synovial capsule is held down firmly to the condyles of the femur, and thus all the soft parts are kept well in place." This mode of operating was also described in 1872 by Brinton.

3. The operation with the **Long Posterior and Short Anterior Flap** has the great disadvantage that the posterior flap has an almost uncontrollable

Fig. 75.—Amputation at the Knee by Lateral Flap.

tendency to retract, and it should never be undertaken when the covering can be obtained more extensively or entirely from the front. It may be readily performed in the following way. An incision is made directly across the knee-joint, just below the patella. The skin-flap thus formed is dissected back; and, the joint being opened above the patella, and the ligaments divided by a few touches of the knife, a long posterior flap is cut from the upper part of the calf of the leg, by passing the knife behind the tibia, and carrying it downwards for a suitable distance.

Amputation through the Condyles may be done in three different ways: 1, with a long anterior flap, including the patella or not; 2, by a modified circular method; 3, with a long posterior flap.

1. Carden, of Worcester, was the first to employ the method of amputation by the **long anterior flap** in this situation. He took away the patella and made no posterior flap; but subsequent operators have found that without a

posterior flap the covering is frequently insufficient. The operation is therefore usually performed as follows: The finger and thumb of the left hand are placed on the two condyloid eminences of the femur, which serve as guides for the starting-points of the incision. A long anterior flap is then marked out, well rounded in shape, and reaching as low as the tubercle of the tibia. This is dissected up either with or without the patella. In cases in which the Surgeon is hesitating between excision and amputation, the joint may be examined before proceeding further and the operation determined on. When the anterior flap has been raised, the knife is passed behind the femur, and a posterior flap, equal in length to the anterior, is cut from within outwards. This flap contains the hamstring tendons, and usually a part of the muscles of the calf, and it consequently retracts considerably after being cut. The flaps being held back, the knife is swept round immediately above the cartilage-covered surfaces, and the saw carried through the bases of the condyles parallel to the articular surface of the femur, that is to say, somewhat obliquely to the

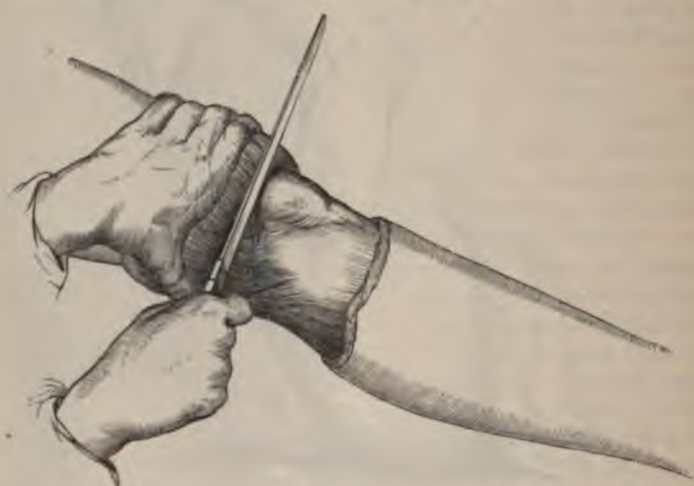

Fig. 76.—Amputation through the Condyles by modified circular method.

axis of the shaft, the inner side being left a little longer than the outer. Gritti, an Italian Surgeon, has recommended that the patella should be left in the flap, and its cartilaginous surface sawn off so as to form a raw bony surface to be applied to the cut end of the femur. Sir William Stokes has modified Gritti's method by dividing the femur half an inch above the condyles instead of through them, thus making the sawn surface of the femur more equal in size to that of the patella, and diminishing the risk of the latter being drawn forwards and upwards off the end of the shaft.

2. Lister has recommended an amputation by a **modified circular method**, which is thus performed: "The Surgeon first cuts transversely across the front of the limb, from side to side, at the level of the tubercle of the tibia, and joins the horns of this incision by carrying the knife at an angle of forty-five rees to the axis of the leg through the skin and fat. The limb being ted, he dissects up the posterior skin flap, and then proceeds to raise the of integument as in a circular operation, taking due care to avoid scoring

the subcutaneous tissue; and, dividing the hamstrings as soon as they are exposed, and bending the knee, he finds no difficulty in reaching the upper border of the patella. He then sinks the knife through the insertion of the quadriceps extensor (Fig. 76), and, having cleared the bone immediately above the articular cartilage and holding the limb horizontally, he applies the saw vertically, and at the same time transversely, to the axis of the limb (not of the bone) so as to ensure a horizontal surface for the patient to rest on." When the soft parts are much thickened, as in disease of the knee-joint, the leg may be removed by dividing the ligamentum patellæ and opening the joint as early as possible. After this the condyles of the femur can usually be protruded and sawn off without difficulty, and the patella removed last of all. If there is still difficulty in protruding the femur an incision may be carried upwards on the outer side as far as may be necessary. The advantage of this operation is that, if it be carefully performed, the chance of sloughing is reduced to a minimum. The pouches of the synovial membrane of the knee must be carefully drained as before described.

3. Amputation through the condyles by the **long posterior flap** should never be performed, unless under exceptional circumstances no other flaps can be obtained.

There is a point of practice that I have found useful in these amputations: viz. to round off with the saw the sharp edge left on the condyle after the removal of its cartilaginous surface, as otherwise this may press injuriously upon the flap.

These amputations present four great advantages over those higher up: 1. As the medullary canal is not opened, the risk of septic osteomyelitis and consequent pyæmia is diminished. 2. The limb being removed at a greater distance from the trunk, the shock will be less and the rate of mortality diminished. 3. The patient is provided with a long thigh-stump, which gives increased leverage in using an artificial limb. 4. When the amputation is practised with the long anterior flap containing the patella, or taking the skin from over it, the end of the stump will be protected by the tough integument naturally situated in front of the knee, which will admit of pressure being made upon it without fear of excoriation: the cicatrix being drawn up behind the end of the stump, and altogether away from its surface.

Results of Amputation through the Knee-joint or Condyles of the Femur.—So far as life is concerned, these operations have been successful. In the American Civil War, of 132 cases, 64 died, giving a mortality of 48·4 per cent. Of these 49 were primary amputations; the deaths among which were 16, or 32·6 per cent. Brinton gives 62 cases of amputation through the knee for disease, with 14 deaths, or 22·6 per cent.

Max Schede gives the results of amputation through the knee-joint in civil practice as follows: for injury, 314 cases, 103 deaths, or 32·8 per cent.; for disease, 123 cases, 30 deaths, or 24·4 per cent.; through the condyles, for injury, 111 cases, 40 deaths, or 36·1 per cent.; for disease, 60 cases, 15 deaths, or 25 per cent.; Gritti's operation for injury, 25 cases, 4 deaths, or 16 per cent.; for disease, 19 cases, 5 deaths, or 26·3 per cent.

AMPUTATIONS OF THE THIGH are commonly required both for accident and for disease. As a rule the operation is most efficiently performed by the antero-posterior flap method, the covering being raised by dissection, not by transfixion. Excellent results may also be obtained in all parts of the thigh

by the circular and modified circular operations. Amputation just above the knee was formerly most often performed by equal lateral flaps cut by transfixion. The fleshy flaps of uniform thickness thus obtained were supposed to form a better covering than the thinner structures in front. But the lateral flaps have the disadvantage of leaving the scar over the bone, and they are difficult to keep in position, and consequently few Surgeons now adopt this method. In other parts of the thigh lateral flaps cannot be conveniently made, as the end of the bone is apt to be drawn up into the angle of the wound, and to project between the flaps, which fall away behind it. In amputation in the lower or middle third, a tourniquet may be applied high on the limb; but when the operation is done in the upper third, there is no space for the application of this instrument, so the hæmorrhage must be arrested by the application of the india-rubber bandage as described on p. 47, by the aortic tourniquet, or by an assistant compressing the artery as it passes over the brim of the pelvis (Fig. 19, p. 53). In whatever situation the Surgeon

Fig. 77.—Amputation of the Lower Third of the Thigh by Lateral Flaps

amputates, he must be careful to carry the knife so as not to split the femoral artery or vein.

Amputation above the Knee by Lateral Flaps, or Vermale's Operation, is thus performed: The outer flap should always be made first. The point of the knife, being entered in the middle of the thigh, about three inches above the upper border of the patella, is carried close round the bone and brought out through the centre of the ham; the flap is then cut downwards and outwards; the knife, being entered again in the upper angle of the incision, is carried close round the bone to its inner side, and the inner flap made by a sweeping cut (Fig. 77). Unless the blade be kept in contact with the bone in this situation, the femoral artery is very apt to be split. The flaps being then retracted, the bone is cleared by two sweeps of the knife, and sawn about four inches above its articular surface.

In all amputations of the thigh by the **Antero-Posterior Flap** method, more or less trouble is apt to arise from the posterior flap being displaced unwards by the divided flexor muscles, which, owing to their great length, for a very considerable distance. Even when the covering may at ve seemed abundant the edges of the wound may separate, leaving a

that no button-hole apertures be made through the heel flap. This may easily be avoided when the soft structures are thickened and infiltrated by inflammatory products; but, if the operation be required for injury, great care is required in digging out the heel, the integuments of the posterior part of the os calcis being very thin and adherent to the bone. It is also of importance that the first incision should be (Figs. 62, 63) distinctly inclined backwards towards the heel, and not forwards into the sole of the foot. Unless this be done, a large cup-shaped flap will be left, in which blood and discharges may accumulate, and retard healing. If union takes place by the second intention, bagging of discharges in the flap must be prevented by uniform elastic pressure and bandaging. The tendency to sloughing occurs chiefly in primary amputations. It has frequently been stated that it is necessary, in order to ensure the vitality of the flap, to cut the posterior tibial artery "as long as possible," and it is this as much as anything that has led to the production of the large cup-shaped flaps which are so difficult to dissect off the os calcis, and which so often slough. An examination of the vascular

Fig. 66.—Line of Incision for Pirogoff's Operation—modified by Oblique Section of the Os Calcis.

supply will show that the posterior tibial artery may be cut close to the base of the flap, without interfering with the chief vessels supplying it. The distribution of vessels to the part is as follows. On the outer side, the peroneal artery, after giving off the anterior peroneal, is continued along the posterior aspect of the fibula to the outer side of the os calcis. On the inner side a branch of considerable size arises from the posterior tibial artery, about one inch above the ankle-joint, and passes down to the inner side of the os calcis, running behind the inner malleolus and accompanying the cutaneous nerve from the posterior tibial to the heel. There is thus a trunk on each side running down to the heel behind the malleolus, and these two communicate freely with each other, superficially over the cutaneous surface of the tendo Achillis, and deeply between the tendon and the ankle-joint; and they terminate by anastomosing by long loops on the under surface of the posterior part of the os calcis. It is upon these anastomosing loops that the vitality of the flap depends; and as they lie much nearer the bone than the skin it is evident that, unless the knife be kept hard upon the bone during

the whole dissection of the flap, they will be divided in large numbers, greatly endangering its vitality. In the operation as performed by Syme, the dissection of the flap is commenced from the most prominent part of the tubercles of the os calcis, and the knife can be kept in constant contact with the bone with the greatest ease. If, on the contrary, the incision extend far into the sole of the foot in front of the tubercles of the os calcis, it is almost impossible to dissect the flap back without the point of the knife being directed into its under surface and the vascular loops being divided.

This operation is a most useful one in all cases requiring removal of the

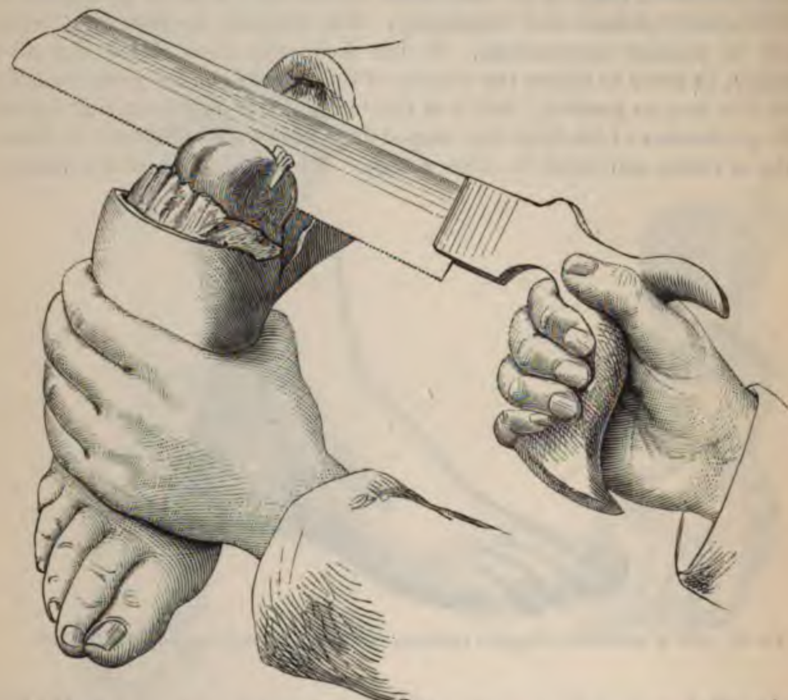

Fig. 67.—Pirogoff's Operation. Sawing the Os Calcis obliquely downwards and forwards.

whole foot. The mortality attending it is but small. The stump that is left admits of the whole weight of the body being borne upon it.

Various modifications of Syme's amputation may at times be practised with advantage, when the soft parts covering the heel are not in a condition to form a good basis of support. In these circumstances, the flaps may be fashioned on the side instead of from behind; and in this way I have more than once formed an excellent covering. These lateral flaps should not, however, be made in any case that admits of disarticulation at the ankle in the ordinary way, as they never afford so good a basis of support as the integuments of the heel.

Pirogoff's Amputation is characterised by the preservation of the posterior portion of the os calcis. In operating on the right side, an incision is carried across the sole of the foot from the tip of the external malleolus to the corre-

this may readily enough be done by dissecting the head out of the acetabulum with a strong scalpel or bistoury.

Results.—The mortality after amputation of the thigh is very considerable when the operation is done for injury, more particularly for compound fracture of the femur itself. The mortality in the older statistics (p. 89) amounted to 59·7 per cent. In the more recent statistics of University College Hospital it is 46·1 per cent. Shock and traumatic gangrene of the stump are the chief causes of death.

The result of amputation of the thigh for disease of the knee-joint depends entirely upon whether the affection is acute or chronic. In acute suppurative disorganisation of the knee, amputation of the thigh is most fatal; indeed, so high is the rate of mortality, that it is doubtful whether it is proper to perform the operation in that stage of the affection. In chronic knee-joint disease, on the other hand, the operation is most satisfactory and successful; death seldom resulting unless the operation has been deferred too long. The average mortality of complicated and uncomplicated cases together in the older statistics was 32·5 per cent. In the more recent statistics of University College Hospital it is 23·5. Max Schede's statistics, in which complicated cases are excluded, gives 63 cases with only one death. The mortality, as before stated (p. 86), increases as the trunk is approached.

Amputation at the Hip-joint.—This formidable operation is of comparatively recent introduction into surgery. During the early part and middle of the last century its practicability was warmly debated in France. It was performed on animals experimentally. It was found that some patients affected with ergotism, whose lower extremities had become gangrenous, and had separated at the hip-joint, survived; and, at last, in the year 1773, the first successful amputation of the kind was performed by Perrault of St. Maure. In the next year, the operation was done in England by Kerr of Northampton, on a girl aged 12, affected with hip-disease and lumbar abscess. The operation was unjustifiable in such a case, but the patient lived 17 days, and thus its practicability was demonstrated. Larrey performed it in 1793 for the first time for gun-shot injury; and since that time the operation has been established in surgical practice, civil as well as military. The operation was first performed successfully in England in 1812, by Brownrigg of Plymouth, on a man whose thigh had been broken in the Peninsular war a year previously.

Amputation at the hip-joint has been performed in a variety of ways which it is not necessary to detail. The following will be described: 1. by combined circular and external vertical incisions; 2. by antero-posterior flaps; 3. by the oval method.

1. The amputation by **combined circular and external vertical incisions** is that usually known as *Furneaux Jordan's method*, although the operation, as now performed, differs in many respects from the description given by that Surgeon. The patient's body is drawn well to the edge of the table, and turned slightly on to the sound side. The thigh of that side is secured in the flexed position by two bandages; one attached to the thigh above the knee by a clove-hitch, the two ends of which are passed round the neck and knotted under the arm of the same side; whilst the second bandage is passed round the sound thigh and secured to the leg of the table beneath the patient's head. The circulation through the limb is controlled by

Esmarch's elastic cord applied in the manner described on p. 47, or by an aortic compressor. An amputating knife of moderate length is to be chosen. The skin and subcutaneous tissues are divided circularly at the junction of the middle and lower thirds of the thigh, and after reflecting them for at least two inches, the muscles are divided circularly down to the bone. The femoral vessels and any others which can be recognized are now ligatured. A vertical incision is next made upwards along the outer side of the thigh from the circular cut to a point midway between the great trochanter and the iliac crest (Fig. 79). The muscles, with or without the periosteum, are turned off the shaft of the femur, and the head is turned out of the acetabulum by dividing the capsule on to the neck of the bone, whilst an assistant rotates the limb according to the direction of the Surgeon. Oozing vessels may now

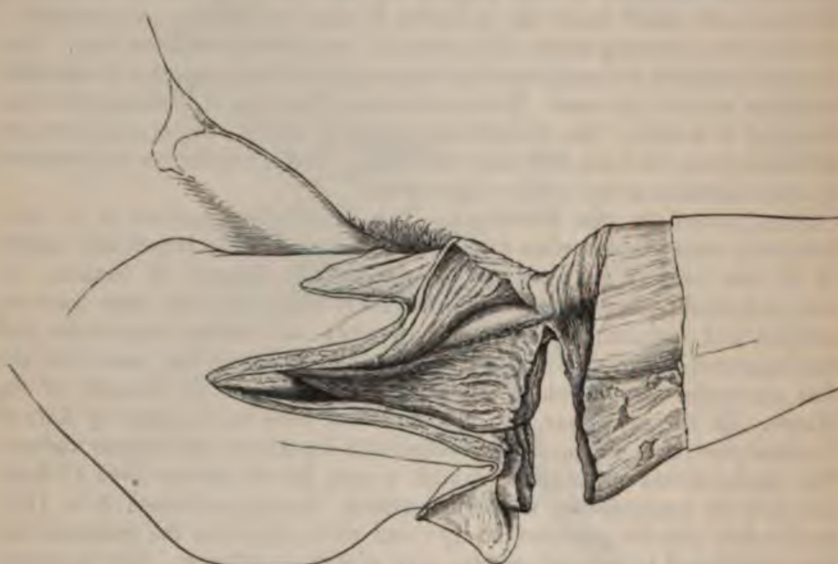

Fig. 79.—Furneaux Jordan's Amputation at the Hip-joint.

be secured before removing the tourniquet. The raw surface is necessarily extensive, and free provision must be made for drainage.

2. Amputation at the hip by **antero-posterior flaps** is the easiest and most speedy method. It consists in making a large and thick anterior flap by transfixion, and a short posterior one from the gluteal region and back part of the thigh. In order to perform this operation properly, the patient's body must be brought well forward upon the edge of the table, so that the nates project beyond it, and be steadied by strong bandages. One of these must be passed between the sound thigh and the perinæum, and attached to the upper end of the table; another should be carried across the pelvis to the lower end; and the sound limb must be tied to the leg of the table.

The Surgeon must have three assistants on whom he can rely. Assistant No. 1 takes charge of the flap, compressing the femoral vessels; and, in the absence of the abdominal compressor, on his trustworthiness the patient's life

is mainly dependent. Assistant No. 2 holds the limb; flexing it slightly on the abdomen in the first stage of the operation, whilst the anterior flap is being made; forcibly abducting, extending, and rotating it outwards during the second stage, when the Surgeon is opening the capsule of the joint; and extending and rotating inwards during the time the posterior flap is being cut. On the way in which he performs these duties the facility with which the Surgeon performs the operation is mainly dependent. To Assistant No. 3 is consigned the care of the instrument used for controlling the circulation. After the removal of the limb, Assistant No. 2 aids the Surgeon in ligaturing the arteries. These preliminaries having been arranged, and the duty of each assistant assigned to him, the operation is to be performed in the following way:

The Surgeon, standing on the left side of the limb to be removed, feels for the bony points which guide his knife, viz. the tuber ischii and the anterior

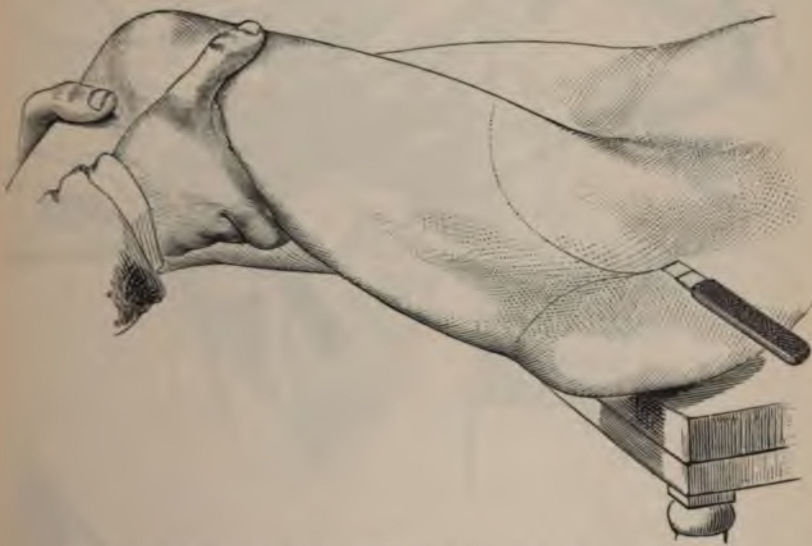

Fig. 80.—Amputation at the Hip-joint: Formation of Anterior Flap in Left Limb.

superior spine of the ilium. The knife, which must have a blade twelve inches long, is entered, and the flap made, in different ways, according to the side of the body on which the operation is performed. If it be on the *left* side, the knife should be entered about two finger's breadths below the anterior superior spine of the ilium, and carried deeply in the limb behind the vessels, directly across the joint, its point being made to issue near the tuberosity of the ischium well behind the prominent ridge formed by the tendon of the adductor longus (Fig. 80). In transfixing on this side, care must be taken not to wound the scrotum or the opposite thigh; the back of the knife must run parallel to Poupart's ligament, and the point must not be directed too much upwards, lest it enter the abdominal cavity. As soon as the point of the knife passes the head of the bone, the handle must be raised so as to direct the point beneath the femoral vessels, lest they be wounded. The aortic compressor does not control the iliac vein, and should the femoral vein be punctured above its

last valve, most dangerous regurgitant hæmorrhage would take place. Transfixion being accomplished, the anterior flap must be cut rapidly downwards about six or eight inches in length. The assistant who is to take charge of the flap passes both hands into the wound above the back of the knife, and grasps the femoral artery firmly between his fingers and thumbs (Fig. 82). As soon as he has thus secured the vessel, the Surgeon turns the edge of the knife forwards and completes the anterior flap. In doing this, care must be taken not to make the flap pointed. This is best done by keeping the edge of the knife turned slightly towards the bone till the point is reached at which it is to be brought out. Also, the assistant who holds the limb must take care not to extend it too soon, but to keep it flexed and slightly adducted until the

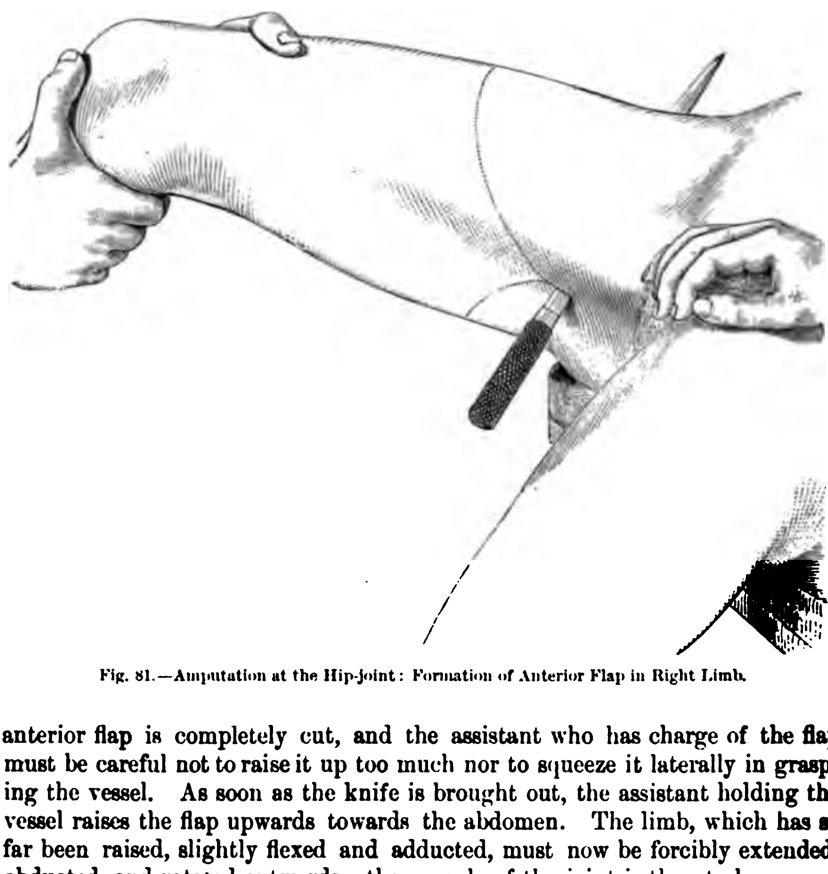

Fig. 81.—Amputation at the Hip-Joint: Formation of Anterior Flap in Right Limb.

anterior flap is completely cut, and the assistant who has charge of the flap must be careful not to raise it up too much nor to squeeze it laterally in grasping the vessel. As soon as the knife is brought out, the assistant holding the vessel raises the flap upwards towards the abdomen. The limb, which has so far been raised, slightly flexed and adducted, must now be forcibly extended, abducted, and rotated outwards; the capsule of the joint is then to be opened by a firm cut with the point of the knife. As soon as this is done, the head of the femur starts out of the socket and the operator touches the round ligament with the point of the knife. The assistant now allows the limb to hang down, and the head of the femur becomes separated by some distance from the acetabulum, and the posterior part of the capsule is brought into view and put on the stretch. This is divided with the point of the knife, and immediately it is done the assistant puts the limb in an extended position in a line with

the body, and at the same time rotates it inwards so that the trochanter shall not catch the knife; the heel of the knife is then passed over the trochanter, and the posterior flap rapidly cut by carrying the knife downwards and backwards through the thick muscles in this situation. The posterior flap may be about four inches in length; but this must, of course, vary according to the length of the anterior flap. When the amputation is performed on the *right* side, the anterior flap is made by entering the knife just above the tuberosity of the ischium, and bringing it out two fingers' breadth below the anterior superior spine of the ilium (Fig. 81); the remaining steps of the operation being performed as in the last case. In transfixing from the inner side, if

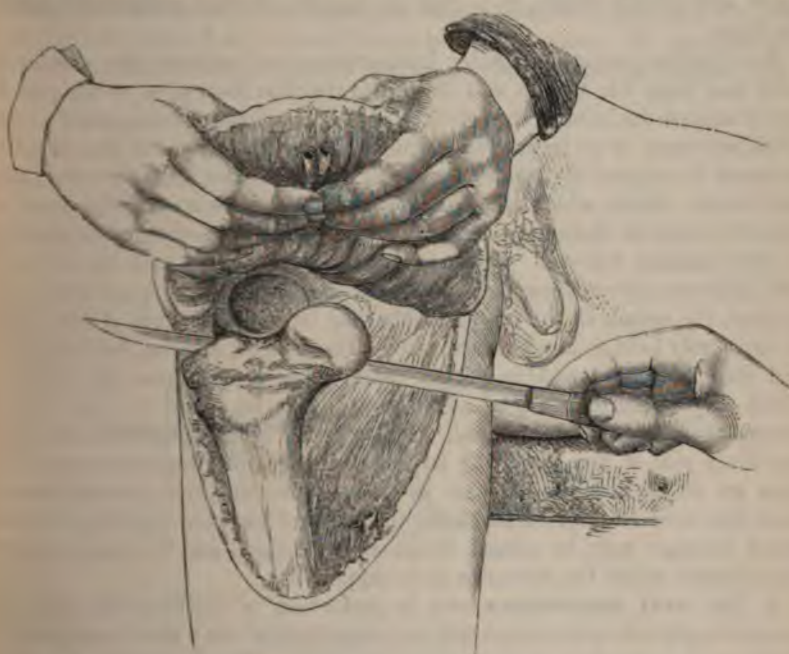

Fig. 82.—Amputation at Hip-joint: Compression of Femoral Artery in Anterior Flap.

the point of the knife be directed too much upwards, it may enter the thyroid foramen.

In order to avoid the inconvenience caused by standing in a cramped position between the patient's thighs, many Surgeons transfix from the outer side on the right limb as well as on the left.

In consequence of the extent to which the limb that is about to be removed may have been injured, or encroached upon by disease, it is not always easy to make the anterior flap of the size or shape described. A little management on the part of the Surgeon will, however, enable him to take the requisite amount of covering from the outer or inner parts by inclining the point or the heel of the knife downwards, as the case may require; or he may make the anterior flap by dissection, instead of by transfixion.

When the femur is entire and unbroken, Assistant No. 2 uses it as a lever, bringing the lower end of it in the second stage of the operation

downwards and outwards, thus causing the head of the bone to press against the anterior part of the capsule, and to start out with a peculiar sucking noise as soon as the latter is opened. Should the bone have been fractured high up, this movement cannot be given to it and the operation is rendered somewhat more difficult. In such a case the Surgeon must grasp the upper end of the femur below the trochanters, so as to steady and push it back as he is disarticulating its head. In two of the cases in which I have amputated at the hip-joint, it has been necessary to do this—in one, in consequence of the crushing of the bone, two inches below the trochanters, by a railway accident; in the other, in consequence of its spontaneous fracture at the junction of its upper and middle thirds, in a case of rapidly growing malignant disease of the bone.

As a further precaution against hæmorrhage the Assistant who steadies the body may press his thumb well down into the iliac fossa so as to compress the artery against the brim of the pelvis. If the tourniquet or compressor is acting efficiently there is no hæmorrhage from the posterior flap, but should the instrument be imperfectly applied there will be free hæmorrhage from the gluteal and sciatic vessels, which must be arrested by the Assistants, who should be ready to compress them with their fingers or with dry sponges, or to seize them in forci-pressure forceps. The arteries may then be ligatured one by one, as the Assistant exposes them. If the other Assistant have a good hold of the femoral, the vessels in the posterior flap may be tied first; but if the femoral be insecurely held, it must be first tied. The femoral arteries, both superficial and deep, will be found to be cut long, and to project from the muscles by which they are surrounded, so as very readily to be seized by the fingers or forceps, pulled out, and ligatured. The arteries in the posterior flap and on the inner side of the joint will be found in the intermuscular septa. The flaps are to be brought together by sutures, two or three drainage-tubes of large size must be inserted, and after the dressing has been applied, a turn of a broad bandage may be passed round the abdomen, and the end brought up from behind under the stump so as to support it.

3. The **oval amputation** may be performed in the following way: The patient is placed on his sound side and the thigh of that side is secured with bandages as in the first method above described. The patient's body must be further steadied by an Assistant placed opposite the shoulders. Another Assistant takes charge of the thigh, and a third, who stands opposite the Surgeon, will take the vessel by thrusting the fingers of one hand into the wound and grasping the artery between them and his thumb. The patient being thus prepared, and the india-rubber band or aortic compressor applied, the Surgeon stands so as to have his left hand to the flaps, that is to say, behind for the right thigh, and in front for the left. An amputating knife of moderate length is to be chosen. The incision is commenced about two inches above the trochanter and carried firmly down to the bone and along the femur to about six or seven inches below the upper end of the bone. At this point the incision is made to bifurcate, one part being carried in a curved direction forwards for about two inches and the other backwards in the same way (Fig. 83, *b*). This marks the point at which the transverse part of the incision is to be made. The limb is now abducted, and, if the first incision has been made with sufficient firmness, the operator will be able to push his thumb into the longitudinal slit which has been made in the lower parts of

the two smaller glutei. The muscles thus being put on the stretch by the Surgeon's thumb, the point of the knife is made to cut over the trochanter and down the upper part of the bone, separating the muscles attached to it, first in front and then behind. The limb is then forcibly adducted, and the Assistant at the same time tries to lift the head of the femur out by putting one of his hands on the inner side of the thigh as high up as possible. The operator then opens the joint by making a firm cut in the line of the superficial incision, so as to make a vertical slit in the capsule and divide the cotyloid ligament, and thus to render dislocation more easy. Another incision is then carried transversely through the capsule in the line of its attachment. The head of the bone then starts from the socket, and the point of the knife is inserted so as to divide the round ligament. If the head does not come out readily, the Assistant may seize the exposed trochanter with a

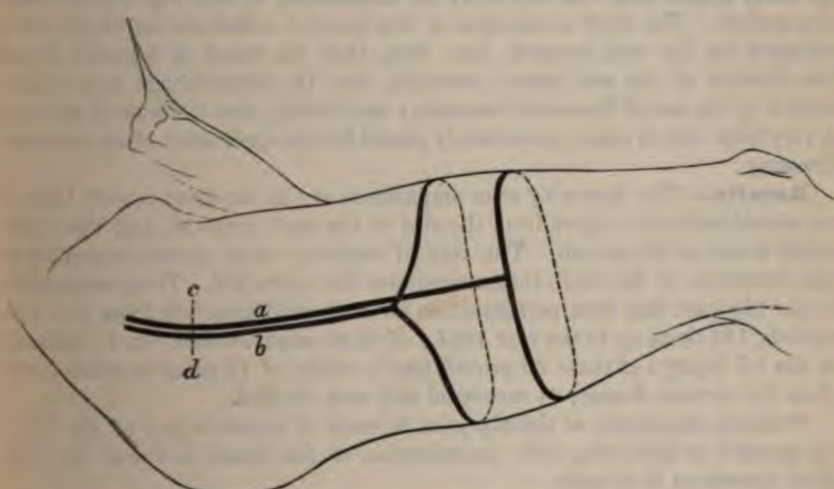

Fig. 82.—Lines of Incision for Amputation at Hip. *a*, Furneaux Jordan's Method; *b*, Oval Method; *c d*, Upper Border of Trochanter.

pair of lion-forceps and drag it forcibly outwards. The remainder of the capsule on the inner side is then cut, and the Assistant can now lay hold of the trochanter and pull it forcibly out of the wound, and the operator, getting his knife to the inner side while he holds the soft parts out of the way with his left hand, gradually separates the bone from its attachments till it is exposed as low as is required. During this part of the operation the limb must still be adducted to the greatest possible extent. Having reached the point at which the commencement of the transverse part of the incision has already been marked, the Surgeon turns the edge of the knife away from the bone and cuts across to the inner side of the limb, thus completing the amputation. During this part of the operation the Assistant must bring the limb into a straight line with the trunk. The artery must be compressed by another Assistant with one hand in the upper part of the wound. If the limb be very muscular it is a good plan, after having enucleated the upper part of the femur, to complete the circular part of the incision by cutting from

part of the thigh from the trochanters to the lower end, where the skin over the patella is included in the anterior flap.

In some instances in which the tissues at the posterior part of the thigh are much diseased or injured, whilst those on the anterior aspect of the limb are sound, a very good stump may be fashioned by making a long square anterior flap, and then cutting at one stroke of the knife through the soft parts at the posterior aspect of the limb, in a somewhat oblique direction from below upwards. The anterior flap, when laid down, will form the cushion at the end of the stump.

Amputation in the lower third of the thigh is sometimes undertaken for

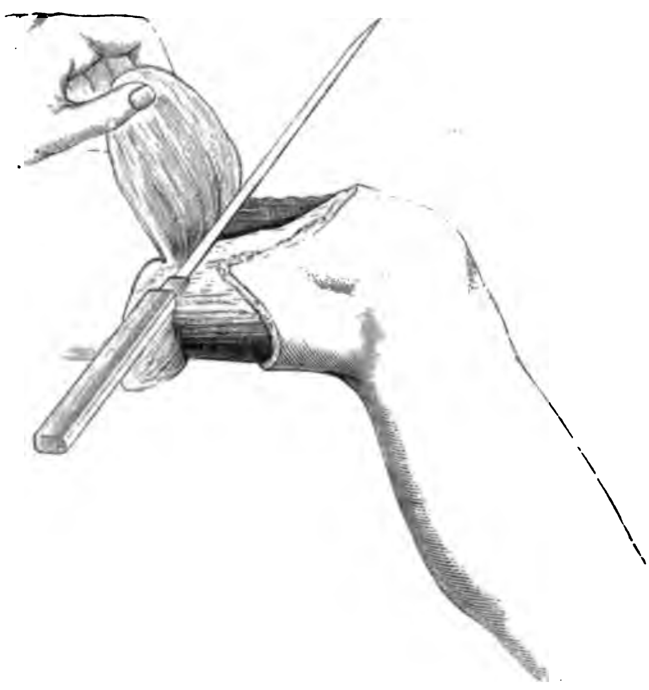

Fig. 78. – Amputation of the Thigh: Flaps cut from without inwards.

spontaneous gangrene of the foot. In such cases the best method is to divide the soft parts on the front of the thigh circularly down to the bone at the level of the upper border of the patella. A very short posterior skin flap is raised, and the soft parts are reflected for at least the length of the diameter of the limb before sawing the bone. Scarcely any interference with the vascular supply of the part is thus caused.

Amputation through the Trochanters may sometimes be advantageously practised, either in severe compound fractures of the lower part of the thigh, or in cases of non-malignant tumours of the lower and middle thirds of the femur; and thus the more severe and dangerous operation of disarticulation at the hip may be avoided. Indeed, should it be found, after section of the bone, that it is so much injured or diseased as to require removal at the joint,

this may readily enough be done by dissecting the head out of the acetabulum with a strong scalpel or bistoury.

Results.—The mortality after amputation of the thigh is very considerable when the operation is done for injury, more particularly for compound fracture of the femur itself. The mortality in the older statistics (p. 89) amounted to 59·7 per cent. In the more recent statistics of University College Hospital it is 46·1 per cent. Shock and traumatic gangrene of the stump are the chief causes of death.

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Amputation at the hip-joint has been performed in a variety of ways which it is not necessary to detail. The following will be described: 1. by combined circular and external vertical incisions; 2. by antero-posterior flaps; 3. by the oval method.

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posterior flap the covering is frequently insufficient. The operation is therefore usually performed as follows: The finger and thumb of the left hand are placed on the two condyloid eminences of the femur, which serve as guides for the starting-points of the incision. A long anterior flap is then marked out, well rounded in shape, and reaching as low as the tubercle of the tibia. This is dissected up either with or without the patella. In cases in which the Surgeon is hesitating between excision and amputation, the joint may be examined before proceeding further and the operation determined on. When the anterior flap has been raised, the knife is passed behind the femur, and a posterior flap, equal in length to the anterior, is cut from within outwards. This flap contains the hamstring tendons, and usually a part of the muscles of the calf, and it consequently retracts considerably after being cut. The flaps being held back, the knife is swept round immediately above the cartilage-covered surfaces, and the saw carried through the bases of the condyles parallel to the articular surface of the femur, that is to say, somewhat obliquely to the

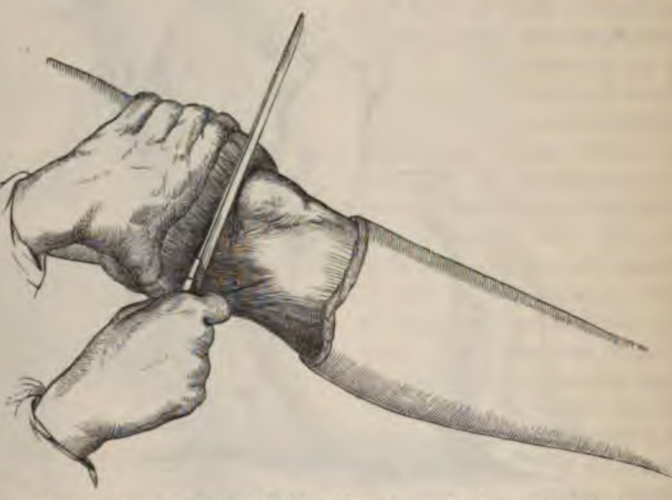

Fig. 76.—Amputation through the Condyles by modified circular method.

axis of the shaft, the inner side being left a little longer than the outer. Gritti, an Italian Surgeon, has recommended that the patella should be left in the flap, and its cartilaginous surface sawn off so as to form a raw bony surface to be applied to the cut end of the femur. Sir William Stokes has modified Gritti's method by dividing the femur half an inch above the condyles instead of through them, thus making the sawn surface of the femur more equal in size to that of the patella, and diminishing the risk of the latter being drawn forwards and upwards off the end of the shaft.

2. Lister has recommended an amputation by a **modified circular method**, which is thus performed: "The Surgeon first cuts transversely across the front of the limb, from side to side, at the level of the tubercle of the tibia, and joins the horns of this incision by carrying the knife at an angle of forty-five degrees to the axis of the leg through the skin and fat. The limb being elevated, he dissects up the posterior skin flap, and then proceeds to raise the ring of integument as in a circular operation, taking due care to avoid scoring

this may readily enough be done by dissecting the head out of the acetabulum with a strong scalpel or bistoury.

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AMPUTATION AT THE HIP-JOINT.—This formidable operation is of comparatively recent introduction into surgery. During the early part and middle of the last century its practicability was warmly debated in France. It was performed on animals experimentally. It was found that some patients affected with ergotism, whose lower extremities had become gangrenous, and had separated at the hip-joint, survived; and, at last, in the year 1773, the first successful amputation of the kind was performed by Perrault of St. Maure. In the next year, the operation was done in England by Kerr of Northampton, on a girl aged 12, affected with hip-disease and lumbar abscess. The operation was unjustifiable in such a case, but the patient lived 17 days, and thus its practicability was demonstrated. Larrey performed it in 1793 for the first time for gun-shot injury; and since that time the operation has been established in surgical practice, civil as well as military. The operation was first performed successfully in England in 1812, by Brownrigg of Plymouth, on a man whose thigh had been broken in the Peninsular war a year previously.

Amputation at the hip-joint has been performed in a variety of ways which it is not necessary to detail. The following will be described: 1. by combined circular and external vertical incisions; 2. by antero-posterior flaps; 3. by the oval method.

1. The amputation by **combined circular and external vertical incisions** is that usually known as *Furneaux Jordan's method*, although the operation, as now performed, differs in many respects from the description given by that Surgeon. The patient's body is drawn well to the edge of the table, and turned slightly on to the sound side. The thigh of that side is secured in the flexed position by two bandages; one attached to the thigh above the knee by a clove-hitch, the two ends of which are passed round the neck and knotted under the arm of the same side; whilst the second bandage is passed round the sound thigh and secured to the leg of the table beneath the patient's head. The circulation through the limb is controlled by

Esmarch's elastic cord applied in the manner described on p. 47, or by an aortic compressor. An amputating knife of moderate length is to be chosen. The skin and subcutaneous tissues are divided circularly at the junction of the middle and lower thirds of the thigh, and after reflecting them for at least two inches, the muscles are divided circularly down to the bone. The femoral vessels and any others which can be recognized are now ligatured. A vertical incision is next made upwards along the outer side of the thigh from the circular cut to a point midway between the great trochanter and the iliac crest (Fig. 79). The muscles, with or without the periosteum, are turned off the shaft of the femur, and the head is turned out of the acetabulum by dividing the capsule on to the neck of the bone, whilst an assistant rotates the limb according to the direction of the Surgeon. Oozing vessels may now

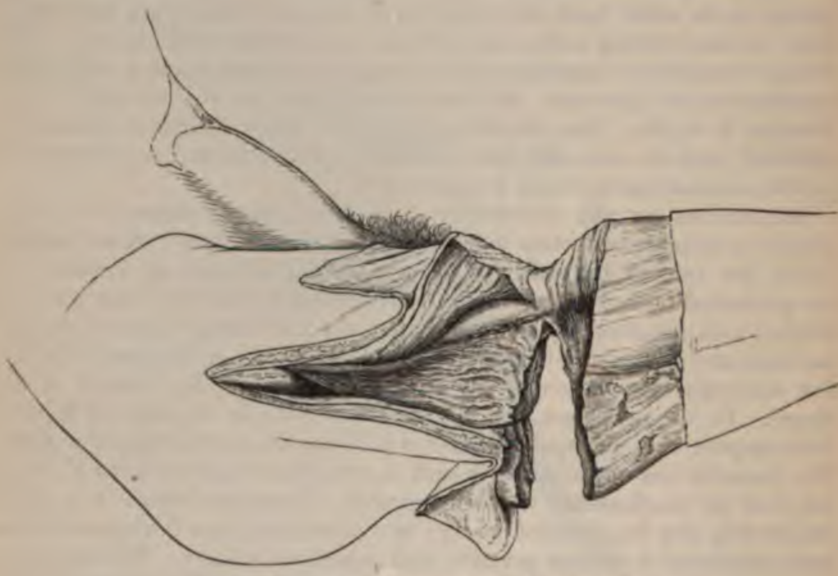

Fig. 79.—Furneaux Jordan's Amputation at the Hip-joint.

be secured before removing the tourniquet. The raw surface is necessarily extensive, and free provision must be made for drainage.

2. Amputation at the hip by **antero-posterior flaps** is the easiest and most speedy method. It consists in making a large and thick anterior flap by transfixion, and a short posterior one from the gluteal region and back part of the thigh. In order to perform this operation properly, the patient's body must be brought well forward upon the edge of the table, so that the nates project beyond it, and be steadied by strong bandages. One of these must be passed between the sound thigh and the perinæum, and attached to the upper end of the table; another should be carried across the pelvis to the lower end; and the sound limb must be tied to the leg of the table.

The Surgeon must have three assistants on whom he can rely. Assistant No. 1 takes charge of the flap, compressing the femoral vessels; and, in the absence of the abdominal compressor, on his trustworthiness the patient's life

is mainly dependent. Assistant No. 2 holds the limb; flexing it slightly on the abdomen in the first stage of the operation, whilst the anterior flap is being made; forcibly abducting, extending, and rotating it outwards during the second stage, when the Surgeon is opening the capsule of the joint; and extending and rotating inwards during the time the posterior flap is being cut. On the way in which he performs these duties the facility with which the Surgeon performs the operation is mainly dependent. To Assistant No. 3 is consigned the care of the instrument used for controlling the circulation. After the removal of the limb, Assistant No. 2 aids the Surgeon in ligaturing the arteries. These preliminaries having been arranged, and the duty of each assistant assigned to him, the operation is to be performed in the following way:

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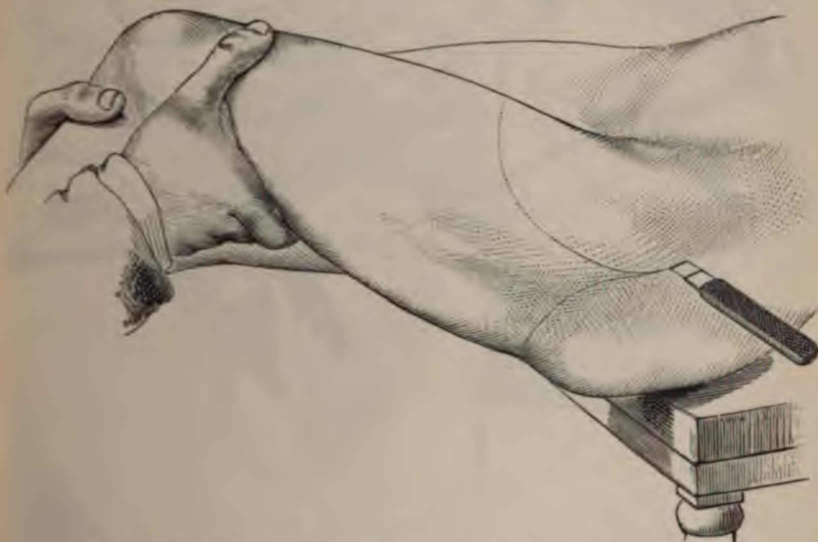

Fig. 80.—Amputation at the Hip-joint: Formation of Anterior Flap in Left Limb.

superior spine of the ilium. The knife, which must have a blade twelve inches long, is entered, and the flap made, in different ways, according to the side of the body on which the operation is performed. If it be on the *left* side, the knife should be entered about two finger's breadths below the anterior superior spine of the ilium, and carried deeply in the limb behind the vessels, directly across the joint, its point being made to issue near the tuberosity of the ischium well behind the prominent ridge formed by the tendon of the adductor longus (Fig. 80). In transfixing on this side, care must be taken not to wound the scrotum or the opposite thigh; the back of the knife must run parallel to Poupart's ligament, and the point must not be directed too much upwards, lest it enter the abdominal cavity. As soon as the point of the knife passes the head of the bone, the handle must be raised so as to direct the point beneath the femoral vessels, lest they be wounded. The aortic compressor does not control the iliac vein, and should the femoral vein be punctured above its

part of the thigh from the trochanters to the lower end, where the skin over the patella is included in the anterior flap.

In some instances in which the tissues at the posterior part of the thigh are much diseased or injured, whilst those on the anterior aspect of the limb are sound, a very good stump may be fashioned by making a long square anterior flap, and then cutting at one stroke of the knife through the soft parts at the posterior aspect of the limb, in a somewhat oblique direction from below upwards. The anterior flap, when laid down, will form the cushion at the end of the stump.

Amputation in the lower third of the thigh is sometimes undertaken for

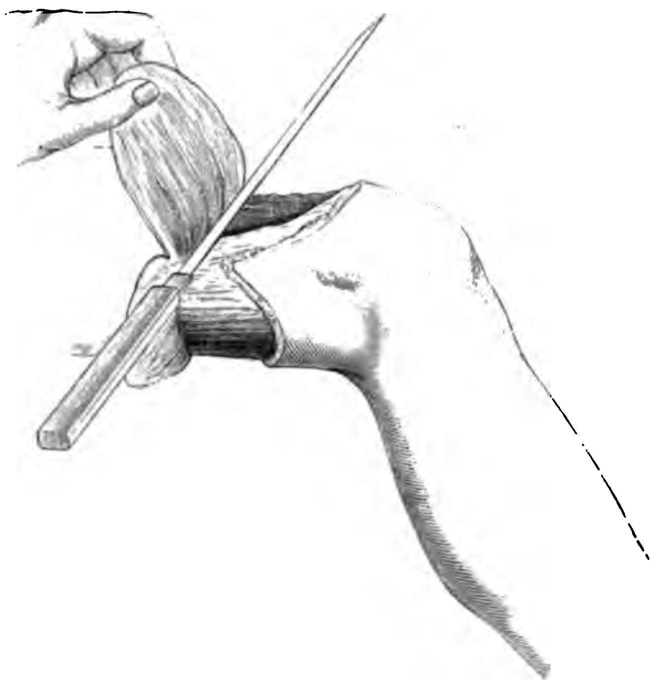

Fig. 78.—Amputation of the Thigh: Flaps cut from without inwards.

spontaneous gangrene of the foot. In such cases the best method is to divide the soft parts on the front of the thigh circularly down to the bone at the level of the upper border of the patella. A very short posterior skin flap is raised, and the soft parts are reflected for at least the length of the diameter of the limb before sawing the bone. Scarcely any interference with the vascular supply of the part is thus caused.

Amputation through the Trochanters may sometimes be advantageously practised, either in severe compound fractures of the lower part of the thigh, or in cases of non-malignant tumours of the lower and middle thirds of the femur; and thus the more severe and dangerous operation of disarticulation at the hip may be avoided. Indeed, should it be found, after section of the bone, that it is so much injured or diseased as to require removal at the joint,

this may readily enough be done by dissecting the head out of the acetabulum with a strong scalpel or bistoury.

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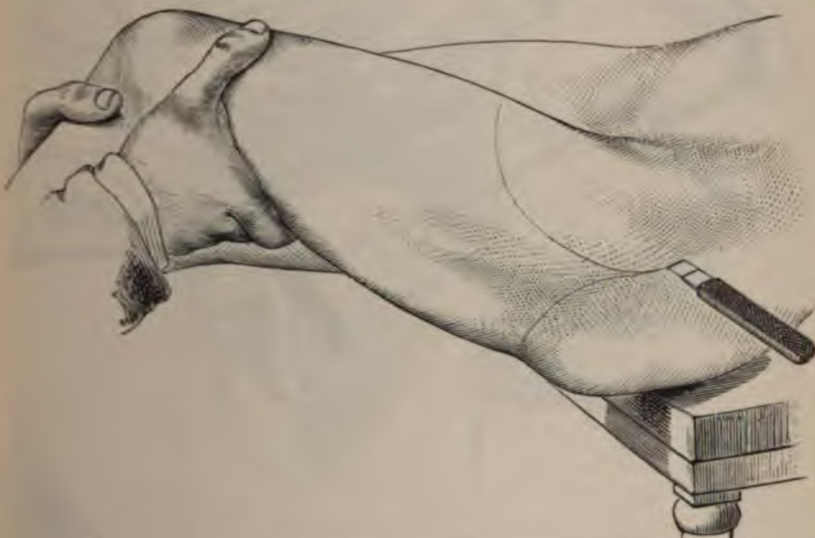

Fig. 80.—Amputation at the Hip-joint: Formation of Anterior Flap in Left Limb.

superior spine of the ilium. The knife, which must have a blade twelve inches long, is entered, and the flap made, in different ways, according to the side of the body on which the operation is performed. If it be on the *left* side, the knife should be entered about two finger's breadths below the anterior superior spine of the ilium, and carried deeply in the limb behind the vessels, directly across the joint, its point being made to issue near the tuberosity of the ischium well behind the prominent ridge formed by the tendon of the adductor longus (Fig. 80). In transfixing on this side, care must be taken not to wound the scrotum or the opposite thigh; the back of the knife must run parallel to Poupart's ligament, and the point must not be directed too much upwards, lest it enter the abdominal cavity. As soon as the point of the knife passes the head of the bone, the handle must be raised so as to direct the point beneath the femoral vessels, lest they be wounded. The aortic compressor does not control the iliac vein, and should the femoral vein be punctured above its

last valve, most dangerous regurgitant hæmorrhage would take place. Transfixion being accomplished, the anterior flap must be cut rapidly downwards about six or eight inches in length. The assistant who is to take charge of the flap passes both hands into the wound above the back of the knife, and grasps the femoral artery firmly between his fingers and thumbs (Fig. 82). As soon as he has thus secured the vessel, the Surgeon turns the edge of the knife forwards and completes the anterior flap. In doing this, care must be taken not to make the flap pointed. This is best done by keeping the edge of the knife turned slightly towards the bone till the point is reached at which it is to be brought out. Also, the assistant who holds the limb must take care not to extend it too soon, but to keep it flexed and slightly adducted until the

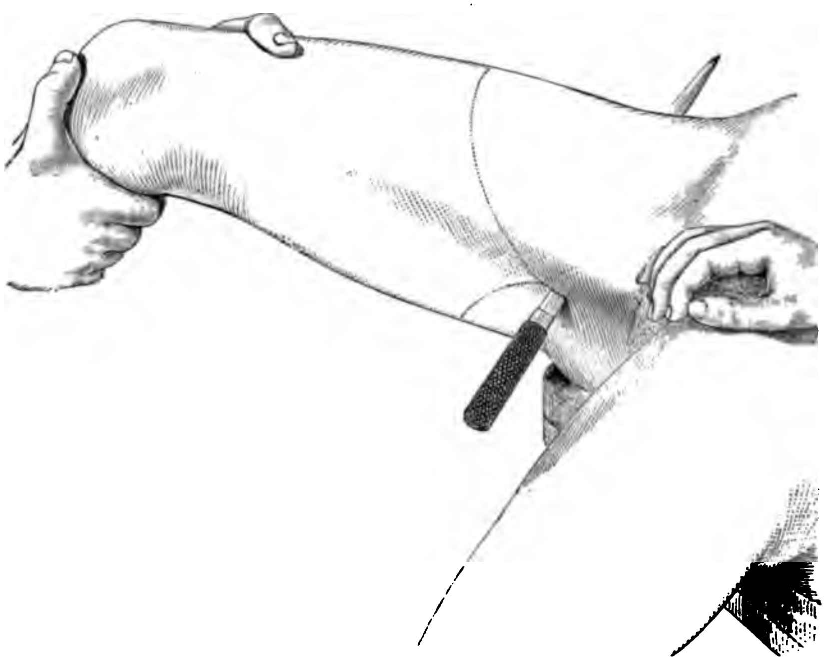

Fig. 81.—Amputation at the Hip-Joint: Formation of Anterior Flap in Right Limb.

anterior flap is completely cut, and the assistant who has charge of the flap must be careful not to raise it up too much nor to squeeze it laterally in grasping the vessel. As soon as the knife is brought out, the assistant holding the vessel raises the flap upwards towards the abdomen. The limb, which has so far been raised, slightly flexed and adducted, must now be forcibly extended, abducted, and rotated outwards; the capsule of the joint is then to be opened by a firm cut with the point of the knife. As soon as this is done, the head of the femur starts out of the socket and the operator touches the round ligament with the point of the knife. The assistant now allows the limb to hang down, and the head of the femur becomes separated by some distance from the acetabulum, and the posterior part of the capsule is brought into view and put on the stretch. This is divided with the point of the knife, and immediately it is done the assistant puts the limb in an extended position in a line with

the body, and at the same time rotates it inwards so that the trochanter shall not catch the knife ; the heel of the knife is then passed over the trochanter, and the posterior flap rapidly cut by carrying the knife downwards and backwards through the thick muscles in this situation. The posterior flap may be about four inches in length ; but this must, of course, vary according to the length of the anterior flap. When the amputation is performed on the *right* side, the anterior flap is made by entering the knife just above the tuberosity of the ischium, and bringing it out two fingers' breadth below the anterior superior spine of the ilium (Fig. 81) ; the remaining steps of the operation being performed as in the last case. In transfixing from the inner side, if

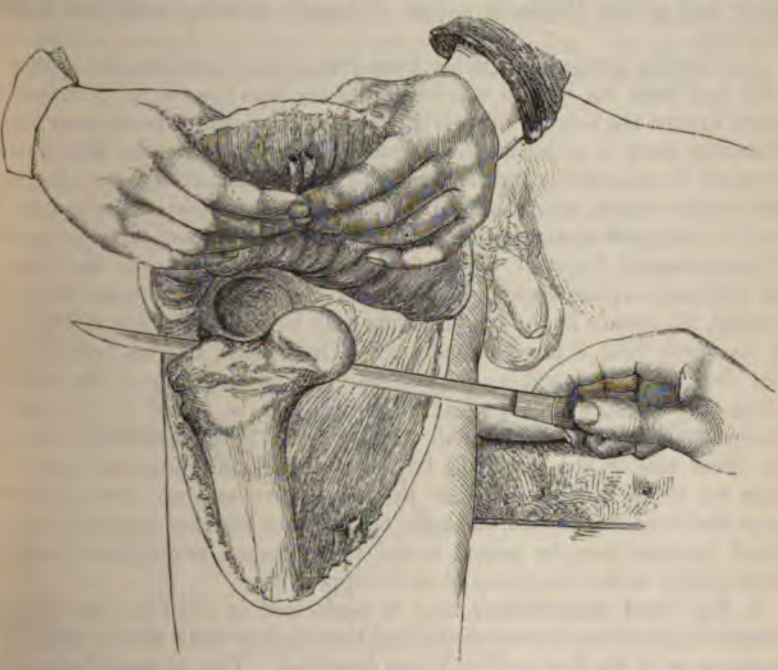

Fig. 82.—Amputation at Hip-joint : Compression of Femoral Artery in Anterior Flap.

the point of the knife be directed too much upwards, it may enter the thyroid foramen.

In order to avoid the inconvenience caused by standing in a cramped position between the patient's thighs, many Surgeons transfix from the outer side on the right limb as well as on the left.

In consequence of the extent to which the limb that is about to be removed may have been injured, or encroached upon by disease, it is not always easy to make the anterior flap of the size or shape described. A little management on the part of the Surgeon will, however, enable him to take the requisite amount of covering from the outer or inner parts by inclining the point or the heel of the knife downwards, as the case may require ; or he may make the anterior flap by dissection, instead of by transfixion.

When the femur is entire and unbroken, Assistant No. 2 uses it as a lever, bringing the lower end of it in the second stage of the operation

downwards and outwards, thus causing the head of the bone to press against the anterior part of the capsule, and to start out with a peculiar sucking noise as soon as the latter is opened. Should the bone have been fractured high up, this movement cannot be given to it and the operation is rendered somewhat more difficult. In such a case the Surgeon must grasp the upper end of the femur below the trochanters, so as to steady and push it back as he is disarticulating its head. In two of the cases in which I have amputated at the hip-joint, it has been necessary to do this—in one, in consequence of the crushing of the bone, two inches below the trochanters, by a railway accident; in the other, in consequence of its spontaneous fracture at the junction of its upper and middle thirds, in a case of rapidly growing malignant disease of the bone.

As a further precaution against hæmorrhage the Assistant who steadies the body may press his thumb well down into the iliac fossa so as to compress the artery against the brim of the pelvis. If the tourniquet or compressor is acting efficiently there is no hæmorrhage from the posterior flap, but should the instrument be imperfectly applied there will be free hæmorrhage from the gluteal and sciatic vessels, which must be arrested by the Assistants, who should be ready to compress them with their fingers or with dry sponges, or to seize them in forci-pressure forceps. The arteries may then be ligatured one by one, as the Assistant exposes them. If the other Assistant have a good hold of the femoral, the vessels in the posterior flap may be tied first; but if the femoral be insecurely held, it must be first tied. The femoral arteries, both superficial and deep, will be found to be cut long, and to project from the muscles by which they are surrounded, so as very readily to be seized by the fingers or forceps, pulled out, and ligatured. The arteries in the posterior flap and on the inner side of the joint will be found in the intermuscular septa. The flaps are to be brought together by sutures, two or three drainage-tubes of large size must be inserted, and after the dressing has been applied, a turn of a broad bandage may be passed round the abdomen, and the end brought up from behind under the stump so as to support it.

3. The **oval amputation** may be performed in the following way: The patient is placed on his sound side and the thigh of that side is secured with bandages as in the first method above described. The patient's body must be further steadied by an Assistant placed opposite the shoulders. Another Assistant takes charge of the thigh, and a third, who stands opposite the Surgeon, will take the vessel by thrusting the fingers of one hand into the wound and grasping the artery between them and his thumb. The patient being thus prepared, and the india-rubber band or aortic compressor applied, the Surgeon stands so as to have his left hand to the flaps, that is to say, behind for the right thigh, and in front for the left. An amputating knife of moderate length is to be chosen. The incision is commenced about two inches above the trochanter and carried firmly down to the bone and along the femur to about six or seven inches below the upper end of the bone. At this point the incision is made to bifurcate, one part being carried in a curved direction forwards for about two inches and the other backwards in the same way (Fig. 83, *b*). This marks the point at which the transverse part of the incision is to be made. The limb is now abducted, and, if the first incision has been made with sufficient firmness, the operator will be able to push his thumb into the longitudinal slit which has been made in the lower parts of

the two smaller glutei. The muscles thus being put on the stretch by the Surgeon's thumb, the point of the knife is made to cut over the trochanter and down the upper part of the bone, separating the muscles attached to it, first in front and then behind. The limb is then forcibly adducted, and the Assistant at the same time tries to lift the head of the femur out by putting one of his hands on the inner side of the thigh as high up as possible. The operator then opens the joint by making a firm cut in the line of the superficial incision, so as to make a vertical slit in the capsule and divide the cotyloid ligament, and thus to render dislocation more easy. Another incision is then carried transversely through the capsule in the line of its attachment. The head of the bone then starts from the socket, and the point of the knife is inserted so as to divide the round ligament. If the head does not come out readily, the Assistant may seize the exposed trochanter with a

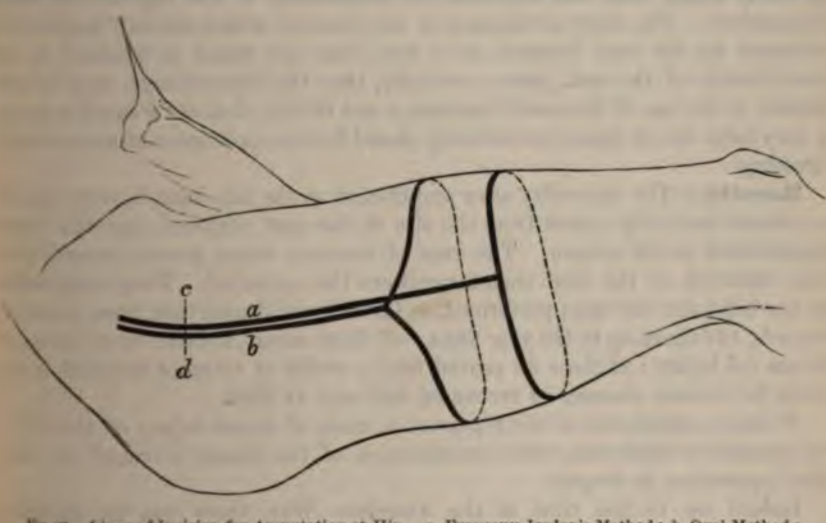

Fig. 53.—Lines of Incision for Amputation at Hip. *a*, Furneaux Jordan's Method; *b*, Oval Method; *c d*, Upper Border of Trochanter.

pair of lion-forceps and drag it forcibly outwards. The remainder of the capsule on the inner side is then cut, and the Assistant can now lay hold of the trochanter and pull it forcibly out of the wound, and the operator, getting his knife to the inner side while he holds the soft parts out of the way with his left hand, gradually separates the bone from its attachments till it is exposed as low as is required. During this part of the operation the limb must still be adducted to the greatest possible extent. Having reached the point at which the commencement of the transverse part of the incision has already been marked, the Surgeon turns the edge of the knife away from the bone and cuts across to the inner side of the limb, thus completing the amputation. During this part of the operation the Assistant must bring the limb into a straight line with the trunk. The artery must be compressed by another Assistant with one hand in the upper part of the wound. If the limb be very muscular it is a good plan, after having enucleated the upper part of the femur, to complete the circular part of the incision by cutting from

without inwards, carrying the incision only through the skin and fat, which may then be turned up for a couple of inches, the muscles being divided last of all at the higher level. The wound must be carefully united with sutures, a large drainage-tube being inserted at the outer side.

In comparing the above methods of disarticulation at the hip-joint, that by transfixion undoubtedly has the advantage of rapidity of performance. In former times this was of the greatest importance, and the operation was often effected in from thirty to forty seconds, and frequently in even less time. With improved means of arresting hæmorrhage time is of less consequence, and the transfixion method has been largely replaced by others. The removal of the limb by circular division of the soft parts low in the thigh, and subsequent removal of the bone through a vertical incision, has very justly gained great favour of recent years; and by the adoption of this principle it may be fairly hoped that the mortality of amputation at the hip will be much diminished. The chief advantages of this method, which are only imperfectly obtained by the oval incision, are: first, that the shock is lessened by the low division of the soft parts; secondly, that the hæmorrhage may be controlled by the use of Esmarch's bandage; and thirdly, that the wound, although a very large one, is more conveniently placed for the application of an antiseptic dressing.

Results.—The mortality after amputation at the hip-joint is very high, as we should naturally expect from the size of the part removed and the consequent shock to the system. The rate of recovery varies greatly according to the condition of the limb that necessitates the operation. Thus, amputation at the hip-joint had been performed, so far as I could ascertain from published records, 126 times up to the year 1864; of these cases, 76 died. In 47 instances it was for injury: of these 35 proved fatal; whilst of 42 cases in which it was done for chronic disease, 24 recovered and only 18 died.

Primary amputation at the hip-joint in cases of severe injury of the thigh, by gunshot or otherwise, with comminution of the femur, is one of the most fatal operations in surgery.

Indeed up to the time of the American War, there was no authentic instance of recovery under these circumstances. But in the elaborate and most able surgical history of that great war, published by the Surgeon-General, 19 cases of primary amputation at the hip-joint for gunshot injury of the femur are related. Of these 11 died from the immediate shock of the operation; 5 died between the 2nd and the 10th day; and 3 recovered. One of these, a man 28 years of age, on whom the operation was performed by Surgeon Shippen, seven hours after the receipt of his wound, was in perfect health in 1892, 29 years afterwards.

Intermediate operations, or those done during the inflammatory period, are very unsuccessful: 18 cases that occurred in the American war were all fatal.

Secondary amputation, in cases of attempted preservation of the limb after severe injuries and gunshot-wounds, has been far more successful. Four cases in which J. Roux practised it in the French campaign of 1859 in Italy all recovered, as did two out of nine in which it was practised in America.

Re-amputation at the hip-joint for diseased thigh-stumps has also been a successful operation: 4 out of 7 American cases recovered.

Max Schede has collected 55 cases of amputation for injury in civil practice with 39 deaths, or 70·90 per cent.

Lüning's carefully collected statistics of amputations for gunshot wounds show the following results: primary amputations—90 cases, 84 deaths, or 93·33 per cent.; intermediate amputations (from second to fourth day)—22 cases, 21 deaths, or 95·45 per cent.; secondary or late amputations—53 cases, 42 deaths, or 79·24 per cent.; amputations in which the date is not stated—65 cases, 60 deaths, or 92·30 per cent.

Amputation at the hip-joint for disease of the femur has undoubtedly become less fatal of late years than formerly. This is owing to the operation being performed at an earlier stage of the disease; to a better selection of cases; possibly to improved methods of after-treatment; but mainly to the influence of anæsthetics, and the control of hæmorrhage by the use of the aortic compressor and elastic band. Max Schede's statistics give 153 cases with a mortality of 65, or 42·68 per cent.

CHAPTER IV.

LOCAL DISTURBANCES OF CIRCULATION AND INFLAMMATION.

THE **regulation of the local supply of blood** to the various parts of the body is accomplished by the smaller arteries, in which the muscular coat is highly developed. When contracted a small artery may completely exclude the blood from the area it supplies, but when fully dilated it admits blood enough to distend every capillary in connection with it. These variations are controlled by the vaso-motor nerves. That stimulation of the sympathetic nerves causes contraction of the muscular coats of the arteries to which they are distributed, and that division of those nerves causes dilatation, has long been known, and there is reason to believe that in addition to these vaso-constrictor nerves, vaso-dilator nerves also exist the stimulation of which causes a dilatation of the vessels to which they pass. All vaso-motor nerves are derived originally from centres in the cord and medulla. Vaso-motor centres are distributed throughout the whole length of the cord, from which fibres pass by the anterior roots either directly to the arteries or else by the rami communicantes to the sympathetic ganglia, and are then distributed to the vessels. The vaso-motor centres in the cord are brought into connection by means of fibres passing upwards in the lateral columns with a general vaso-motor centre in the upper part of the medulla. Stimulation of this centre causes a general contraction of the vessels throughout the body, and consequently an increase of resistance and an elevation of the blood-pressure; paralysis of the centre causes an opposite effect. Cortical centres influencing the circulation have also been discovered in the motor area and in the gyrus fornicatus. The former of these, if stimulated, causes an effect on the opposite side only, while the latter produces a general effect, probably through the general centre in the medulla. Lastly, it is believed that microscopic ganglia exist on the vessels themselves, for if a part be completely separated by division of its nerves from the centres, the vessels which are at first paralysed gradually recover their tone more or less completely.

The veins possess a certain degree of tone as well as the arteries, and this is under a similar nervous control.

Variations in the calibre of the vessels may be produced, first, by direct action on the vessels themselves, as by heat, cold or injury; and secondly, by the action of the centres in the cord, medulla or brain. The action of the centres may be called into play or inhibited directly, as by injury, or by the quantity or quality of the blood circulating through them, or by the action of drugs; or indirectly by afferent stimuli. Thus the circulation of venous blood through the centres, as in asphyxia, or an insufficient quantity, as in profuse hæmorrhage, causes at first a stimulation of the general vaso-motor centre and a contraction of the vessels. Afferent stimuli act locally or

generally. Thus an emotional stimulus may cause dilatation of the vessels of the face, as in blushing; or pallor, as in fear. Stimulation of a sensory nerve, especially if prolonged and severe, causes dilatation of the vessels in the area supplied by it. Still more violent afferent impulses may lead to a general relaxation of the vessels throughout the body by temporarily paralysing the general vaso-motor centre, and this is supposed to form an important element in the condition known as shock after injury.

This brief sketch of the mechanism by which the circulation is regulated generally and locally is sufficient to show how complex the processes are by which local anæmia and hyperæmia are induced, and how impossible it is, in the present state of our knowledge, fully to explain all these variations in the supply of blood.

The local circulation is also influenced to a great degree by the condition of the heart. Any disease impairing its force predisposes to passive congestion or anæmia of distant parts of the body.

The **Local disturbances of the circulation** are of three kinds: Local Anæmia; Active Hyperæmia, Active Congestion, Fluxion or Determination of Blood; and Passive Hyperæmia or Passive Congestion.

LOCAL ANÆMIA.

Local Anæmia may be complete and permanent, as in obliteration of the arteries leading to a part by coagula, by disease of their coats, by pressure from without, or from a wound. Complete anæmia may result also from diffused pressure acting on the capillaries. This condition necessarily leads to the death of the part, and will be considered when treating of gangrene. Anæmia may also be incomplete and permanent from the same causes acting in a less degree. Whenever from any cause the arteries leading to a part are permanently diminished in calibre, the amount of blood circulating through the area supplied by them must be diminished, and the tissues suffer in proportion to the diminution. Such a condition is very common in old people from degenerative changes in the arteries. Under such circumstances the nutrition is impaired. If the part be external, as, for example, a limb, it is colder than natural; the growth of the epithelium is imperfect, and the surface is often dry and scaly; the nails are brittle and grow slowly; the muscles are weak and are liable to irregular painful contractions or cramp. The power of resistance to external injuries is lessened: a slight degree of cold causes gangrene; wounds tend to slough; ulceration occurs readily in the skin from superficial abrasions; and inflammation arises from causes which would fail to produce it in a healthy part, as the feeble tissues are unable to offer sufficient resistance to invading pathogenic organisms or to withstand the irritating effects of the products of putrefaction. Permanent local anæmia acts therefore as a most important predisposing cause of inflammation.

Temporary local anæmia may be produced intentionally by the Surgeon, as in the bloodless method of operating already described, or by pressure applied to arrest bleeding. Direct stimulation of the muscular coat of the artery, as by mechanical violence or cold or a certain degree of heat, may cause a temporary anæmia. The same condition may result from reflex causes. As familiar examples of temporary local anæmia, we may take the dead-white colour of fingers or toes from exposure to cold

and the anæmia of the brain with insensibility, which occurs in the condition known as concussion after a blow on the head. In the affection known as Raynaud's disease, a vaso-motor spasm occurs in symmetrical areas, most commonly the fingers, toes or ears, causing complete anæmia of the part, sometimes of such duration as to end in gangrene. Local anæmia of one part may also result from hyperæmia of another, as the amount of blood in the body is not nearly sufficient to distend all the vessels fully. An example of this is the faintness, from anæmia of the brain, which results from immersing the body in a hot bath, by which the whole of the cutaneous vessels become widely dilated, thus more or less draining the internal parts. In whatever way temporary local anæmia is produced, it ceases as soon as the cause is removed, and is replaced by hyperæmia, varying in intensity with the duration and degree of the previous anæmia. Familiar examples of this are: the red glow that succeeds when the fingers recover after having been "dead" with cold, and the blush and oozing of blood that follow the removal of the tourniquet in bloodless methods of operating.

ACTIVE LOCAL HYPERÆMIA, ACTIVE CONGESTION, DETERMINATION OF BLOOD OR FLUXION.

Active Congestion is an increased flow of blood to a part, owing to a dilatation of the arteries from relaxation of their muscular coat. Determination of blood is often very transitory, and frequently occurs as a normal process when, for temporary purposes, an increased supply of blood is called for by a particular organ.

Causes.—An increased local supply of blood is intimately associated with most surgical processes. The separation of dead parts, the repair of wounds and the healing of ulcers cannot take place without it. Every vascular tissue is susceptible of it; and in active processes in non-vascular tissues it occurs in the nearest vessels. The Surgeon often excites it intentionally as one of the most efficient of his therapeutic means. Under some circumstances, therefore, it can scarcely be considered a morbid condition. It is, however, frequently associated with disease, forming as it does an essential part of all inflammatory processes.

Hyperæmia always follows temporary anæmia of a part, as from cold or pressure, and the contraction of the vessels that occurs on stimulation of the sympathetic is likewise followed after a longer or shorter interval by relaxation with active congestion. Arterial dilatation is often reflex: thus the irritation of a sensory nerve usually causes immediate dilatation of the vessels in the area supplied by it. Another marked example of reflex hyperæmia is the engorgement of the kidney that often follows operations upon the urethra, and may terminate fatally. An irritant applied directly to a part may cause dilatation of the vessels in two ways: first, in a reflex manner by acting on the sensory nerves of the part; and, secondly, by acting injuriously on the arteries themselves, and paralysing their muscular coats. Thus, a blister when first applied causes redness by acting on the sensory nerves; but after it has been on some time, its action extends sufficiently deeply to exert a directly injurious influence on the vessels themselves. This latter condition is a part of true inflammation. Hyperæmia always accompanies the exercise of function; it occurs in glands during secretion, in muscles during exertion, &c. To this class of causes may also be referred the various forms of normal determination,

such as erection, or the enlargement of the mammary vessels during pregnancy. Lastly, anæmia of one part may be associated with hyperæmia of another, contraction of the arteries in the one causing a reflex dilatation of the vessels of the other. Thus exposure of the surface to cold may cause hyperæmia of the lungs, intestines, or kidneys.

Symptoms.—The symptoms of determination of blood, as seen in an external part, are those that we should expect to result from an increased quantity of blood rushing with increased velocity through the affected textures. They are as follows: Redness of a bright scarlet hue, swelling or rather fulness of the part from turgescence of the vessels, heat appreciable to the Surgeon's hand as well as to the patient's own sensations, a feeling of tension and throbbing, with an increase in the quantity of the secretions of the part.

Effects.—The effects of simple hyperæmia can rarely be studied uncomplicated by other conditions. It may, however, be broadly stated, that so long as the walls of the vessel are healthy, mere increased flow of blood causes no evil consequences in the affected area. In all cases in which it is the result of local irritation, it is complicated by a greater or less degree of true inflammation. In cases of hyperæmia from pressure upon the sympathetic in the neck, there is some fulness of the face but no actual œdema, and in many cases profuse sweating of the affected side of the face occurs. It gives rise to no tendency to capillary hæmorrhage, provided the vessels are healthy; but long-continued or frequently repeated determination of blood causes permanent dilatation of the capillaries and some thickening of their walls. In glandular organs active hyperæmia causes an excessive flow of secretion. Thus constantly repeated hyperæmia of the genital organs from the sexual impulses of youth not uncommonly give rise to a slight increase in the secretion of the prostate and urethra which is often a cause of needless and morbid anxiety. Occasionally it may cause hypertrophy; thus, the skin may assume a warty appearance from hypertrophy of its papillæ in the hyperæmic area round an ulcer, and sometimes there may be an excessive growth of hair from the same cause.

PASSIVE CONGESTION.

Passive Congestion or **Passive Hyperæmia** plays an important part in pathology; it gives rise to serious structural changes, and acts as a powerful predisposing cause of inflammation. It consists in accumulation of blood in the affected part from interference with its free return towards the heart. The blood in the affected area is not only greatly increased in quantity, but it circulates languidly, and, from its prolonged stay in the capillaries, it becomes more completely deoxidised than natural, and is consequently of a darker colour. The arteries are, at most, of their normal size, or even may be contracted, while the veins and capillaries are distended. When the circulation in the congested part becomes completely arrested, *stagnation* is said to occur.

Causes.—The causes of passive hyperæmia may be grouped under the following heads:—1. Diminution or loss of any of the natural forces engaged in maintaining the circulation; 2. Abnormal resistance, *a*, in the veins, *b*, in the capillaries, and *c*, in the arteries; 3. The force of gravity.

1. The three great forces concerned in maintaining the circulation are, the force of the heart, the aspiratory force of respiration, and muscular contrac-

tions in the limbs driving the blood along the veins in the direction determined by the arrangement of the valves. Extreme weakness of the heart's action is a common cause of passive congestion, its propulsive power not being sufficient to overcome the normal resistance in the capillaries, which consequently become gorged with blood. Thus we see congestion of the extremities in exhausting fevers, and the same condition readily occurs in old people. The diminution of the aspiratory force of respiration seldom plays an important part in the causation of passive congestion, but it no doubt aids in the production of those passive congestions of the viscera so commonly met with in patients dying gradually of exhausting diseases. The coldness and congestion of paralysed limbs furnish a good example of passive hyperæmia due to failure of the third force above mentioned. Passive congestion from this cause however more commonly arises from incompetence of the valves of the veins—a condition met with in all cases of varicose dilatation. When the valves are no longer competent, pressure upon a part of a vein will drive the contained blood backwards towards the capillaries, almost as readily as forwards towards the heart.

2. *Increased resistance* to the flow of blood (*a*) *through the veins* is the most common cause and produces the most typical form of passive congestion. The cause of obstruction may be inside or outside the vein, the former being such conditions as pressure of tumours, or of fæces on the pelvic veins, partial strangulation (as in hernia), &c.; and the latter, coagulation of blood in the vein, with or without inflammation of its coats, as in white leg after labour.

(*b*) *Increased resistance in the capillaries* and smaller veins of such a kind as to give rise to congestion is met with as a consequence of altered vital relations between the walls of the vessels and the contained blood, of such a kind that the corpuscles show an unnatural tendency to adhere and thus retard the blood-stream. This is an essential feature of inflammation, and will be described with that process.

(*c*) *Increased resistance in the arteries* is a common cause of passive hyperæmia. Thus, in old people, the arteries of the legs are frequently narrowed by degenerative changes in their coats to such an extent that, although allowing sufficient blood to pass to fill the vessels beyond, the force of the heart is almost completely expended before the blood reaches the veins, and thus partial stagnation, with accumulation in the capillaries, takes place. The most extreme congestion is also met with when a small terminal artery, *i.e.* one whose branches have no anastomosis with neighbouring arteries, suddenly becomes plugged by an embolon; that is to say, by a solid body, such as a clot washed into it by the blood-stream. As an immediate effect of the obliteration of the vessel the area supplied by it becomes more or less completely bloodless, but before long it is found to be gorged with blood. This process of hæmorrhagic infarction, as it is termed, occurs in the lung, spleen, and kidney. According to Cohnheim, the blood which distends the vessels in the congested area enters by regurgitation from the surrounding capillaries and veins. These infarcts are always found in the superficial parts of the affected organs, and Litton, in opposition to Cohnheim's view, maintains that the blood finds its way into the anæmic area from the small arteries of the pleura in the lung, or of the capsule in the spleen or kidney, and not by regurgitation from surrounding vessels.

A somewhat similar condition of intense passive congestion is very frequently

met with by the Surgeon in undermined portions of skin which have been deprived of their direct arterial supply by destruction of the subcutaneous tissue, as in phlegmonous erysipelas or superficial strumous abscesses. The blue undermined skin thus produced may hover between life and death for months, delaying healing indefinitely, and at last requiring destruction before a cure can be obtained.

3. The force of gravity plays an important part in many cases as a cause of passive congestion, especially in the pelvic viscera, the veins of which are unprovided with valves. Its effects are, however, even more marked in the leg when, as the result of disease, the valves have become incompetent. Under these circumstances the increased pressure leads to dilatation of the veins and capillaries, and consequently retards the flow of blood through them. This condition is termed hypostatic congestion. The most familiar examples are congestion of the legs from continued standing, and of the posterior part of the lungs of those who have been long confined to a recumbent position.

Any of the above causes may act singly or in combination with others.

Effects.—These are of much surgical importance. The first change that usually takes place is transudation of the more watery constituents of the blood into the surrounding tissues. Hence the spaces of the areolar tissue are distended by the effused fluid, giving rise to the condition known as *œdema.*

If the turgidity of the vessels be great, and especially if their walls be unhealthy, rupture will occur, and hæmorrhage from the surface or into the substance of the part will ensue. Observations made on the frog's foot after ligature of the main vein show, however, that in moderately intense congestion, the red corpuscles pass through the walls of the capillaries into the surrounding tissues, without any apparent rupture, by a process of diapedesis. This may occur with the passage of very few white corpuscles provided the vessels are healthy. The red corpuscles that thus escape from the vessels break up and are absorbed, but some of the altered blood-pigment remains behind and causes the grey pigmentation of mucous membranes or the brown colouring of the skin, which is so characteristic of repeated or long-continued congestion.

Induration from the growth of fibroid tissue, chiefly around the distended vessels, is an almost constant effect of repeated or long-continued passive congestion. But although the affected part may be increased in bulk, the normal tissue is atrophied from the pressure of the new growth. Perhaps the best illustration of this process is afforded by the *nutmeg liver* that is frequently found associated with obstructive disease of the heart. It may be said briefly that the two most marked *post-mortem* signs of prolonged or repeated passive congestion are pigmentation and induration.

The most important effect, however, of passive hyperæmia is the lowering of the vitality of the affected part, rendering it prone to inflame or ulcerate from slight causes. In congestion, although the part contains a great excess of blood at any given time, this is not changed with sufficient frequency, and consequently the amount that circulates is really less than natural.

Symptoms.—Passive congestion of an external part may be readily recognised by the changes it induces in the colour, the size, the feel, the temperature, and the functions of the part. The colour ranges from dark red to bluish purple, but if the affected part has been exposed frequently to pre-

vious attacks of congestion, it may be darkly pigmented and brown in colour; it is increased in size; if the congestion is recent and acute, it is soft from œdema, and pits under the pressure of the finger; if it is old and chronic, the tissues are indurated and brawny. The patient is conscious of a heavy, dull, aching sensation, scarcely amounting to pain, but yet attended with uneasiness. The temperature is never above, but often below, the normal standard, and the functions are lessened in activity.

The existence of congestion in an internal organ may be ascertained by finding its size increased and its functions modified, with a sensation of weight in it. The symptoms are often, however, very obscure.

Treatment.—No treatment of passive congestion can be completely successful unless the cause can be removed. The first indication consists in the removal of any source of obstruction to the return of blood from the part, as by loosening a tight bandage, or elevating a part that has been too long dependent. If the congestion be due to the feeble action of the heart, stimulants and digitalis may be of service in relieving it.

The next indication consists in lessening the quantity of blood in the congested part. The mere removal of the obstructing cause may effect this; but the desired effect is often hastened by the direct removal of blood by scarification, or by the application of leeches. The over-distended vessels may in some cases be relieved by promoting a free secretion from the part, as by the administration of purgatives for portal congestion. In some parts, again, the judicious application of pressure by means of a bandage will prevent or relieve congestion by limiting œdema and by compressing the dilated vessels, and so causing the blood to flow more rapidly through them, provided the pressure be not sufficiently powerful to interfere with the current through the arteries. With this view elastic pressure is applied to support varicose veins in the leg, and to diminish the mechanical hyperæmia of the skin that usually accompanies them.

The third indication in the treatment of congestion consists in stimulating contraction of the dilated vessels by the direct application of an astringent to them; thus we apply nitrate of silver to congested mucous membranes, and cold douches to many external forms of passive hyperæmia.

STRANGULATION.

Strangulation is the obstruction of the circulation caused by a narrow circle of pressure acting both upon the arteries and veins, as when a tight bandage is applied round a limb. Strangulation may be at once complete, the circulation through both arteries and veins being simultaneously arrested, as by the application of the tourniquet. The circulation below the band is at once arrested, but no visible changes occur in the part, nor would they do so till gangrene and decomposition commenced. In cases in which strangulation is accidental or pathological it is more commonly incomplete at first; the obstruction acts first on the veins, owing to the lower blood-pressure within them, the flow through the arteries continuing. As a consequence of this the phenomena of passive congestion appear in their most intense form; the parts below the constriction are gorged with blood, purple or black in colour, and become cold and numb. There is great swelling, and often abundant escape of red corpuscles from the vessels, or rupture of the capillaries with extrava-

sation of blood. As the part swells the constriction becomes tighter, the obstruction to the arterial flow increases, till finally the circulation is completely arrested and gangrene sets in.

ACUTE INFLAMMATION.

The study of the process of inflammation is one of the most important upon which the Surgeon can enter, for not only does it give him an insight into the greater part of the Science of Surgery, but the treatment of inflammation, as it affects the different tissues and organs, forms an essential part of his duties. However interesting the theory of inflammation may be, it is impossible to discuss it here otherwise than in outline; to gain a fuller acquaintance with it the works on general pathology and the writings of those who have made it a subject of special investigation must be consulted.

The scientific study of inflammation may be said to date from the publication of John Hunter's celebrated "Treatise on the Blood, Inflammation and Gun-shot Wounds." His knowledge was, however, necessarily limited by his not having at command the means of observing the process in the living tissues of animals. As soon as the improvements in the microscope rendered this mode of investigation possible it was actively prosecuted in this country by C. J. B. Williams, Addison and Travers, Waller, Wharton Jones and Paget, all of whom made important additions to our knowledge. Hunter, and most of his more immediate followers, regarded inflammation as a process in which the normal acts of nutrition were, although altered and perverted, more active than in health. Paget, on the other hand, had observed and accurately described the degenerative changes to be observed in tissues affected by acute inflammation. In 1858, Lister, continuing this line of observation, arrived at the conclusion that the essential feature of the acute inflammatory process is a more or less complete suspension of functional activity in the affected tissues as a consequence of some injurious influence acting upon them. This theory being, however, difficult to reconcile with the "Cellular Pathology" of Virchow, in so far as that system referred to inflammation, met with but little favour till after the rediscovery by Cohnheim in 1867 of the migration of the white corpuscles of the blood from the vessels during inflammation, a process by which the appearance of new cells in an acutely inflamed area was fully accounted for, without the necessity of supposing any increased activity, either nutritive or formative, in the original tissues of the part during the early stages of the process. Burdon-Sanderson, therefore, in 1870, defined inflammation thus: "Inflammation is the succession of changes which occurs in a living tissue when it is injured, provided that the injury is not of such a degree as at once to destroy its structure and vitality."

During the last few years, Metchnikoff, and many others who have followed him, have added much to our knowledge of the process by a comparative study of the effects of injury and disease in all forms of animal life from the amœba upwards.

In the study of inflammation it is most important to bear in mind that the process is always the result of some injurious influence acting on the living tissues, and if the cause be removed the process will cease. It is not a disease in itself; it is in fact in most cases, if not in all, the defensive reaction of the tissues against the injurious influence acting upon them. The new cells that

invade the inflamed area are engaged in removing the portions of tissue which may have perished from the injury, or in combating the micro-organisms which may have invaded the affected area, or should the process be due to the action of a chemical irritant, the abundant exudation from the vessels tends to dilute or wash away the irritating material, and thus to bring the process to an end.

Our knowledge of inflammation has been largely derived from observation of the process artificially induced in some transparent tissue of a living animal. The web of the foot and the mesentery of the frog, and the tongue of the toad have been chiefly made use of. In order to prove that the processes observed in the frog are identical with those that occur in mammals under similar circumstances, the wing of the bat was used by Paget, and subsequently the mesentery of the rabbit was successfully experimented on. Lastly, Hueter, by observations made on the mucous membrane of the lip, showed that the processes in man are identical with those that occur in the lower animals. Microscopic examination of prepared specimens of inflamed human tissues also shows appearances which are readily explained by what is seen to take place during actual observation of the process of inflammation in the frog.

If the web of a frog's foot be spread out and examined with the microscope, the blood is seen to flow in a continuous stream through the small arteries, capillaries and veins. In any vessel which is of sufficient size to allow several corpuscles to pass at the same time, the red corpuscles flow in the centre of the stream, forming a yellow line, while on each side of this is a colourless zone, free from red corpuscles, known as the inert or plasmatic layer. In the inert layer is seen an occasional colourless corpuscle, passing somewhat lazily along, with some tendency to adhere to the wall of the vessel. If from any cause the stream be slow enough to allow of the individual red corpuscles being observed, it will be seen that they show no tendency to adhere to each other or to the wall of the vessel; although, as every one knows, when removed from the influence of the living vessels they show a remarkable degree of adhesiveness, sticking not only to each other but to every solid body with which they come in contact. The arteries show constant slight variations in calibre, which are not rhythmical, and are dependent on causes the exact nature of which is uncertain. The flow through the capillaries varies in rapidity with the state of the arteries, being more rapid when they are dilated and slower when they are contracted. In observing the foot of the frog, there will also be seen a beautiful system of branched cells containing pigment-granules, by means of which the animal is able to change the tint of its skin. When the pigment is collected into a closely packed mass round the nucleus of the cell, the frog is pale; when it is diffused evenly throughout the whole cell, the animal becomes of a darker tint. These variations of tint occur under the influence of light, the frog becoming pale when exposed to bright light and dark under the opposite condition. Thus, then, in the healthy web, there are three phenomena of easy observation, which indicate the vital activity of the tissues—the want of adhesiveness of the corpuscles, the variations in the calibre of the artery and the movement of the pigment cells. There is yet another sign of health which is not to be observed with equal ease, and that is that the capillaries allow no more serum to exude through their walls than is necessary for the healthy nutrition of the surrounding tissues, and the amount is such that any excess can be readily drained away by the lymphatics.

Supposing now that some irritating substance be applied to the web, the

normal phenomena just described will be disturbed proportionately to the potency of the irritant employed, or, in other words, to the degree of injury done to the tissues, provided that the injury is not sufficient to cause the immediate death of the tissues. The immediate effect is, in most cases, a *dilatation of the arteries*, with an *increased flow of blood* to the area injured. This is spoken of as **determination of blood to the part,—active hyperæmia,—active congestion—or fluxion.** Some irritants, such as ammonia or mechanical violence, cause *contraction* which precedes the dilatation, but this is always of brief continuance and of but little importance. The widening of the artery allows a greater quantity of blood to flow into the capillaries, which consequently become dilated in their turn. Many which in the contracted state contained no corpuscles, and were consequently invisible, now become apparent as the increased blood stream enters them, and thus new vessels seem to start into existence. The flow through the capillaries is at the same time accelerated. After a short time the dilatation extends to the vein. It would seem at first sight that dilatations of the channels through which the blood is flowing would lead to a slackening of the current rather than to increased rapidity of flow; and so it would, if the dilatation occurred equally in arteries, capillaries and veins,—but this is not the case. The small arteries are capable of very great variations in size, sometimes contracting almost to obliteration and again expanding to many times their ordinary calibre. The capillaries, on the other hand, are capable of proportionally much less dilatation, and such widening as does take place is purely passive and a consequence of the increased pressure caused by the relaxation of the arteries. The artery in a dilated state will admit to the capillaries it supplies many times the quantity of blood it allows to pass when contracted, but the combined sectional area of the capillaries is increased only by a fractional part. It is evident, therefore, that the rapidity of the flow must be increased.

The cause of the arterial dilatation is twofold. It has been shown by experiment that irritation of a sensory nerve causes dilatation of the arteries in the whole area supplied by that nerve. This is a purely reflex phenomenon. Part therefore of the dilatation is due to this cause, and is not accurately limited to the area injured. In the damaged area itself, however, the dilatation is chiefly due to the direct effect produced upon the vessels of the part by the injury that has caused the disturbance; here the muscular tissue of the small arteries is paralysed. That this is so is further shown by the fact that the degree of the dilatation is fixed and uniform, all those variations before mentioned as occurring in health being absent.

If the irritant applied to the web of the frog's foot be more powerful, it will be difficult to observe either the stage of contraction, supposing it to occur, or the stage of dilatation with increased rapidity of flow, for before the microscope can be brought to bear on the web the circulation will have undergone a third change. The vessel will be dilated as widely as possible, but *the flow of blood, instead of being increased in rapidity, will be retarded or even arrested.* In order to observe the development of this state of the circulation with greater accuracy the mesentery of the frog may be made use of, and no further irritation than exposure to the air should be applied. In a mesentery, properly prepared and protected from needless sources of irritation, the retardation of the blood-stream may be delayed for many hours. Coinci-

dently with the first signs of retardation of the blood-stream, a change is observed in the relation of the corpuscles to each other and to the walls of the vessels. They no longer flow freely and separately onwards, but show an adhesiveness not observed before, in consequence of which they tend to stick to each other and to the wall of the vessel through which they are passing. Even in health the colourless corpuscles show some degree of adhesiveness and are to be seen rolling along the wall of the vessel in the inert layer. It is not surprising, therefore, that the first signs of increased adhesiveness are noticed in the white corpuscles, which fall out of the axial stream more and more and adhere to the walls of the vessels, while the red continue to pass onwards. Thus, after a short time, a great increase of colourless corpuscles is observed in the vessels of the inflamed area; and in the small veins, in which the force of the circulation is least, they soon form a uniform layer, almost like an epithelium, adhering to the inner coat of the vessel. They are, as it were, filtered out of the passing blood, the red moving on whilst they remain behind. After a short time, as the vitality of the mesentery fails, the red corpuscles also begin to be arrested in their passage through the vessels, first in the veins and capillaries, and finally in the arteries. In the capillaries, owing to the small size of the vessels, which mostly allow only a single line of corpuscles to pass, the separation of the colourless corpuscles from the red cannot take place, and here we find the red and white mixed together. In the small arteries the first sign of retardation is that a few corpuscles stick to the inner coat during diastole of the heart, and are driven on at the next systole; and thus the stream, which in health is uniform in the more minute arteries, becomes pulsating. As the vitality of the part sinks still lower the accumulation of corpuscles increases till the vessels become choked; the red corpuscles forming, in the frog, a yellowish mass in which the individual cells cannot be recognised. All circulation is thus arrested—a condition known as **"stasis."** Immediately before stasis becomes complete a slight movement forward may be noticed with each systole of the heart, followed by a return of the corpuscles to their former situation during diastole, an appearance to which the name of **"oscillation"** is given. The time occupied in the development of complete stasis is entirely dependent on the nature of the injury which causes it. It may be induced instantaneously by the application of any strong irritant to the web of a frog's foot; while, in a carefully tended mesentery, its advent may be delayed for a whole day or even longer. It is evident that stasis involves a complete arrest of nutrition, which must, unless relieved, inevitably end in the death of the affected tissues before long. Should this occur, the plasma which still remains in small quantity amongst the closely packed corpuscles coagulates, and stasis becomes converted into **thrombosis**; that is to say, plugging of vessels with coagulated blood. On the other hand, should the tissues not be injured beyond recovery, the condition of stasis gradually passes off: at first some oscillatory movement is noticed; then a few of the corpuscles at the margins begin to break away into the blood-stream, and finally they all seem to lose the tendency to stick to each other or to the vessel, and move off, and the circulation gradually resumes its normal character.

The retarded flow and stasis are degrees of the same condition, and it remains now to consider the causes which bring it about. In the healthy state of the circulation, as before stated, the corpuscles show no tendency to

adhere to each other or to the walls of the vessels through which they are flowing; on the other hand, both red and white corpuscles show a very considerable degree of adhesiveness when removed from the body. In sticking to each other and to the walls of the vessels, they are therefore behaving in the living body as if they were in contact with dead matter; and the conclusion derived from this is, that in the healthy living tissues there are forces at work, of the nature of which we are ignorant, which counteract the natural adhesiveness of the corpuscles; but that when the vitality of a part is lowered by damage of any kind, this power is diminished or lost, according to the degree of injury the tissues have suffered, and consequently the natural adhesiveness of the corpuscles comes into play, causing increased resistance to the flow through the vessels and a corresponding degree of retardation of the blood-stream. The accumulation of the white corpuscles is explained by the fact that they possess a greater degree of adhesiveness than the red; their form also favours their adhesion to the sides of the vessels. That the change is not in the corpuscles themselves, nor in the plasma, is shown by the fact that, if an irritant be applied to a very small area, so that a corpuscle can be watched through it, it will be seen that the adhesiveness shows itself only while the corpuscle is in the affected area: the moment it passes beyond it, it moves freely on as before. That the retardation of the flow is not the cause of the adhesion of the corpuscles is shown by the fact that, if a ligature be placed tightly round the limb of the frog so as to arrest circulation entirely, no adhesion of the corpuscles to each other or to the vessels is observed till the tissues begin to lose their vitality—a condition which, in the frog, will not come on for twenty-four hours. Cohnheim attributes all the phenomena of inflammation in the first place to molecular changes, accompanied by loss of vitality, in the walls of the vessels; and probably in many cases of inflammation in which the source of irritation is carried to the part by the vessels their walls suffer first. No doubt also, if the vessels could escape in the case of a local injury, such as the application of mustard to the web of a frog's foot, the vascular phenomena of inflammation could not occur. But it is impossible, even in imagination, to separate the tissues from the capillaries in vascular parts; and whether the source of damage comes from without or from within the vessels, if it is of sufficient power to cause inflammation, the surrounding tissues practically must suffer with the vessels. In the experiments on the frog's foot, Lister showed that the movements of the pigment in the branched cells ceased whenever the flow in the vessels was retarded, proving that they suffered equally with the vessels from the effects of the irritant.

Having thus traced the changes that can be readily observed in the circulation of an inflamed part, we must now turn our attention to **the processes observed in the surrounding tissues and in the walls of the vessels themselves**. For this purpose the web of the frog's foot is not well suited: the mesentery of the frog or the tongue of the toad is more convenient for observation. Supposing the mesentery to have been exposed and prepared for examination, the first effect observed will be the dilatation of the vessels; but if proper precautions be taken, the vitality of the part will not for two or more hours be sufficiently lowered by simple exposure to the air to cause retardation of the flow. By the application of an irritant, it might be induced instantaneously, but this would needlessly confuse the experiment. As soon as retardation sets in, the accumulation of corpuscles takes place as before described.

If a small vein in which the white corpuscles have arranged themselves along its walls be now watched, the following phenomena will be observed. An individual corpuscle being chosen and carefully watched, a small button-like projection will be seen to rise from the outer wall of the vessel, opposite the point to which it is adhering; this gradually increases in size till it becomes a hemispherical prominence corresponding in width to the remainder of the corpuscle within the lumen of the vein. As the external part increases, that inside the vessel is seen to diminish till the greater part comes to lie outside. It then assumes the form of a pear-shaped body attached to the vein by a stalk, which finally gives way, and the corpuscle is free outside the vessel. When the process of migration is completed, the contour of the vessel remains unchanged, no visible rupture of its coats being observable. The migrated

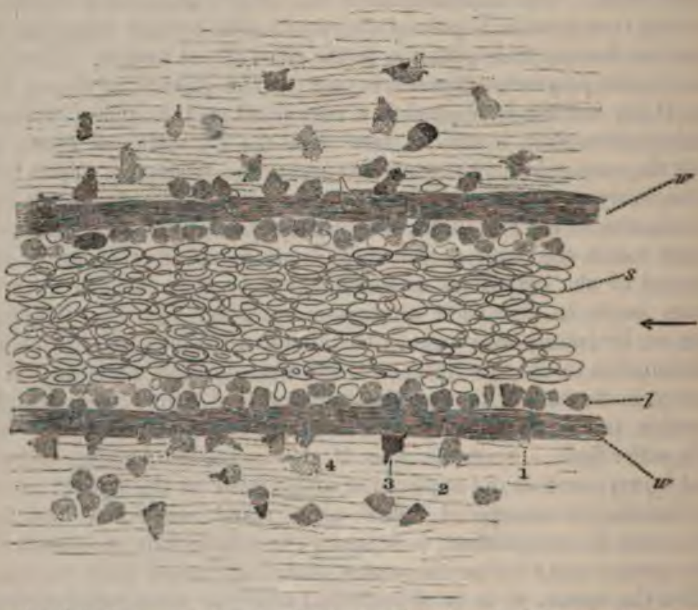

Fig. 84.—Migration of the Leucocytes, from a small vein. *w.* Wall of vessel. *l.* Leucocyte-layer on inner side of the vessel wall. 1, 2, 3, and 4, Leucocytes in different stages of migration. *s.* Red blood corpuscles (axial stream).

corpuscle is irregular in shape, can be seen to shoot out delicate processes in various directions, which are drawn in again, and thus it moves farther and farther away from the vessel in which it formerly lay. From the close resemblance of these changes of form to those observed in the amœba, they have received the name of "amœboid movements." The whole process is known as **migration of the white corpuscles.** Fig. 84, which was drawn from life by Horsley, beautifully illustrates the process of migration. It shows the appearances in the mesentery of a frog which had been exposed for seven hours. The circulation was vigorous in the direction indicated by the arrow. At the commencement of observation there was scarcely a leucocyte outside the vessel wall. One hour and a half after there were about three times the number represented in the drawing, the excess having been omitted for the sake of clearness. The corpuscles, 1, 2, 3, and 4 in and on the wall of the

vessel, are consecutive forms assumed by one corpuscle which was watched through the wall of the small vein. The outlines of the red corpuscles are indicated for the sake of clearness, but the current was too rapid during life to admit of their being seen as drawn.

As long ago as 1841, C. J. B. Williams pointed out the fact that the white corpuscles are present in augmented numbers in the vessels of an inflamed part; but it was Addison, who, in the same year, first described their migration from the vessels. This observation was confirmed by Augustus Waller in 1846; but its importance was not recognised even by those who had observed it, and it was in fact generally doubted, till Cohnheim in 1867, published an accurate account of the process, and pointed out its bearing on the pathology of inflammation.

As a result of this process of migration of the corpuscles, the tissues of an inflamed part soon become crowded with wandering leucocytes, which may accumulate in such numbers as to conceal the normal structures more or less completely. As the inflammatory process becomes more intense, red corpuscles also leave the vessels, finding their way out chiefly from the capillaries, in the same way as has already been described as occurring in mechanical hyperæmia. The number that escape will depend very much on the degree of obstruction caused by the choking of the capillaries by adherent corpuscles. The migrating cells were at one time supposed to find their way out by natural openings or "stomata," which were believed to exist in the walls of the capillaries between the single layer of endothelial cells, of which these vessels are composed. Although no definite openings are now supposed to exist, yet it is probable that the migrating corpuscles do pass out between the cells, the natural adhesion of which to each other is lessened by those changes in the vascular walls which form an essential part of the inflammatory process. The force that causes the escape of the corpuscles differs in the case of the red and white respectively. The red are forced out by the intravascular pressure only, being themselves entirely passive. The white corpuscles make their way out by their own amœboid movements, aided by the pressure within the vessels. The latter force is doubtless of great importance, for ligature of the main artery leading to the inflamed area diminishes or even arrests the process of migration. The observations of Leber, Metchnikoff, and many others have lately tended to show that the passage of the corpuscles from the vessels and their subsequent movements in the tissues are very largely influenced by the various chemical substances which may be present in the fluids of the inflamed part. These substances are in a very great proportion of all acute inflammations the products of the growth of the micro-organisms which are the immediate cause of the process. Much evidence has been brought forward to prove that the protoplasm of the leucocyte is influenced by some substances in such a way as not only to stimulate its movements but to determine them in such a direction that the corpuscle moves towards the attractive substance. Other substances produce the opposite effect and repel the corpuscles. This action of chemical substances upon motile cells of all kinds, whether animal or vegetable, has received the name of *chemiotaxis*, the process of attraction being called *positive*, and that of repulsion *negative*, chemiotaxis. The extreme advocates of the theory of chemiotaxis are inclined to look upon it as the sole cause of migration and to maintain that the corpuscles only leave the vessels

under the stimulating influence of some positively chemiotactic substance attracting them from without, the condition of the vessel-wall being a matter of minor importance. But it is well known that migration is the immediate effect of all injuries, whether mechanical, physical, or chemical, which damage the tissues to such an extent as temporarily to suspend their activity without actually destroying their vitality. No better example of this can be given than Cohnheim's experiment of simply excluding the blood from the ear of a rabbit for a sufficient length of time to cause a distinct impairment of vitality. On readmitting the blood abundant migration takes place. It is easy to say that during the exclusion of blood bacteria have invaded the tissues or that the tissues have themselves produced a positively chemiotactic substance, but there is no proof that anything of the kind takes place, and there is no reason at present to abandon the view that a damaged condition of the walls of the vessels is a most important factor in the process of migration. It seems equally certain that migration cannot take place in the presence of a chemical substance which arrests the amœboid movements of the corpuscles, whatever may be the condition of the walls of the vessels. It is clear also that the same substance in a high degree of concentration may arrest migration, while in a lower degree it may stimulate the movements of the corpuscles. While accepting therefore chemiotaxis as an established fact, there seems no reason to regard it as more than one of the factors concerned in the process of migration.

With the migration of the corpuscles occurs another process of equal importance—the escape of an abundant liquid exudation. It has before been stated (see Congestion) that an increase of the intravascular pressure, such as is produced by any obstruction to the return of blood through the veins, causes an abundant liquid exudation from the distended vessels. While the vessels themselves are healthy they continue to act as filters to the fluid passing through, and the effused liquid contains but little albumen, with a large proportion of salts, and is not spontaneously coagulable. In inflammation, the power of filtration is diminished, till in the higher degrees the damaged vessels allow the plasma to pass through almost if not absolutely unchanged. Inflammatory exudation is therefore much richer in albumen than the simple transudation from pressure, and is spontaneously coagulable. Its ready coagulability is due not only to its containing a larger proportion of fibrinogen, but to the presence in it of the white corpuscles which contain the other element necessary for coagulation—the "fibrin-ferment." As this exudation takes place into tissues, the vitality of which is lowered by the damage done to them by the cause of the inflammation to such a degree that they are behaving for the time being as dead matter, all the essentials for coagulation are present, and the inflammatory effusion tends to coagulate in the affected area. In the process of coagulation some of the migrated white corpuscles break up, yielding their ferment to form the coagulum; but a vast number remain unchanged entangled in the meshes of the fibrin. The coagulated exudation contracts, just as the ordinary blood-clot does out of the body, and the serum finds its way by the lymphatics back into the circulation. The remaining clot, entangling in its meshes the wandering leucocytes, forms the so-called **inflammatory lymph**, which distends the spaces of the tissue into which the exudation has taken place. The formation of this inflammatory lymph is limited to the area of inflammation, for any of the effused plasma

which soaks beyond the area into the surrounding healthy tissues, will no longer tend to coagulate, but will drain off by the lymphatics and return to the circulation. The same will happen with any migrating corpuscles which wander beyond the area of inflammation. If the exudation is very abundant, the lymph-spaces for some distance round the centre of inflammation will be distended with fluid, and thus is produced the œdema which accompanies all acute inflammatory processes. The amount of exudation from an inflamed part is very considerable. Experiments have shown that the amount of lymph returned through the main lymphatic trunk of the thigh of a dog after inflammation has been excited in the paw, is many times the normal quantity, about one ounce escaping for every drachm that could be collected before the inflammation had been set up.

The Migrated Corpuscles in the Tissues.—We have seen in the foregoing description of the intravascular changes in inflammation that both red and white corpuscles and probably also the blood tablets may pass through the walls of the vessels into the surrounding tissues. The red corpuscles take no part in any pathological process outside the vessels. Their escape is merely an accident, and they are soon absorbed by other cells. Of the blood tablets outside the vessels we know nothing.

It is now known that the blood contains more than one form of colourless corpuscle—how many is not determined. Microscopically two chief varieties are easily recognized, one having a single large round or oval nucleus surrounded by a comparatively small amount of protoplasm, and the other having a lobed or more commonly a completely divided nucleus consisting of three or four parts surrounded by a larger amount of protoplasm. The breaking up of the nucleus has been looked upon by many pathologists rather as a sign of degeneration than of activity, for the reason that it is always found in pus-cells which are evidently dead. It seems, however, that this explanation is erroneous, for not only are the multinucleated leucocytes abundantly present in the blood, but they form at least three quarters of the migrating cells and are the most active when they have left the vessels. Metchnikoff states that the division of the nucleus greatly facilitates the passage of the corpuscle through the vessel-wall. The first function of the escaped leucocytes is to *take part in the coagulation of the exuded plasma.* A certain number of the corpuscles break up, yielding the fibrin-ferment necessary for coagulation, while the rest remain entangled in the meshes of the fibrin. As before mentioned, this forms the so-called *inflammatory lymph.* There can be little doubt that the corpuscles which thus break up are of a different variety from those that remain unchanged. Secondly, the migrated leucocytes move towards the damaged area, and invade it until the original tissues may be scarcely recognisable amongst the crowd of invading cells. This movement towards the damaged area has been explained by supposing that the damaged tissues, being in a state of suspended activity, offer less resistance than the surrounding healthy parts, and that the corpuscles therefore move in the direction of least resistance. On the other hand, the theory of attraction or chemiotaxis (p. 161) is now adopted by a large number of pathologists. It is quite evident that this movement towards the damaged area will be arrested, should the part be impregnated with any chemical substance which is capable of inhibiting the amœboid corpuscles, or of destroying their vitality. In considering the movements of the leucocytes, it must be remembered that

the flow of lymph is from the inflamed area, while the movement of the corpuscles is towards it, a fact which gives considerable support to the attraction theory.

When the migrated cells have thus infiltrated the area which has been injured by the noxious agent that has caused the inflammation, it is generally accepted as a fact that under favourable circumstances they penetrate and consume any portions of tissue which may have been actually killed, thus as it were scavenging the injured area, and preparing the way for repair. The least complicated example of this is seen in the simple traumatic inflammation that occurs in a healthy incised wound during the first few hours after its infliction. Here the leucocytes have but little to do and are undisturbed by the presence of micro-organisms and their products.

The great majority of acute inflammations are, however, caused by the invasion of the affected part by micro-organisms and by the soaking of their chemical products into the surrounding tissues. Under these circumstances the leucocytes invading the affected area are found to have taken the organisms into their substance just as they do cinnabar and other foreign bodies in the blood. About this fact there is no difference of opinion, but the explanation of it has given rise to much discussion, and may still be said to be a subject of dispute.

On the one hand, Metchnikoff and his followers regard the leucocytes as the defenders of the body from the attacks of the invading microbes. They explain the process of inflammation thus. Supposing a micro-organism to have effected a lodgment in the tissues of an animal, certain chemical substances are produced by its growth which become diffused in the surrounding tissues. In some cases these products are of such a nature as to arrest the movements of the leucocytes, or even to repel them (negative chemiotaxis), and under these circumstances no migration takes place, and the invasion of the micro-organism goes on undisturbed, leading frequently to the death of the animal. In other cases the products of the growth of the micro-organism exert an attractive influence on the white corpuscles (positive chemiotaxis), and thus cause abundant migration and infiltration of the affected area with leucocytes. The leucocytes on arriving at the affected area seize on the invading organisms, taking them into their substance, as an amœba does its prey, and destroying them by a process of intracellular digestion, thus bringing the process of invasion to an end, and curing the disease. Again, it is maintained that the products of the growth of the invading organism when diluted at some distance from the centre of invasion, attract the leucocytes by positive chemiotaxis. The migrating corpuscles moving towards the centre of infection are gradually exposed to a more intense action of the chemical substance, and their movements are arrested and finally they perish, becoming pus-cells.

This process of eating up dead tissues or invading organisms has received the name of *phagocytosis*, and the cells possessing the power of so doing are called *phagocytes*. It will be seen subsequently that many other cells can act as phagocytes besides the white corpuscles, but in all probability during the acute stage of inflammation, when the original tissues of this part are suffering from the damage done by the cause of this process, the leucocytes are the only cells capable of actively exerting their phagocytic properties.

Metchnikoff regards the process of phagocytosis as the essence of inflamma-

tion—so much so that he says "the essential and primordial element of a typical inflammation consists in a reaction of phagocytes against a noxious agent." This view may be correct as regards inflammation caused by an invading organism, but the simplest and most typical inflammation is that caused by mechanical violence, and here the process of cell emigration and exudation can hardly be regarded as defensive, as it does not take place till after the noxious agent has ceased to act. To regard the phagocytic action of leucocytes and other cells as the whole of inflammation seems to be taking too narrow a view of the process.

In opposition to Metchnikoff, Büchner and many others are of opinion that the amœboid cells merely take into their substance organisms which are already dead, and while granting to the fullest extent the scavenging powers of the migrated cells, they deny their defensive action against invading organisms.

Metchnikoff supports his views by a comparative study of the behaviour of motile cells under injury in all classes of animals, from the unicellular organisms to mammalia, and brings forward a large amount of evidence in favour of his views. The whole subject of phagocytosis as a defensive process will be considered again in the Chapter on Infective Diseases.

Lastly, the leucocytes have been credited with the function of taking part in the formation of new tissue. Within a few years of Cohnheim's re-discovery of the migration of the colourless corpuscles this view was almost universally accepted. All the latest observations, however, tend to the opposite view, and the opinion most generally held now is that after having served their purpose as scavengers or as the first line of defence against invading organisms, they are themselves absorbed by other phagocytes derived from the original tissues, or pass back into the lymph stream. Whether migrated leucocytes can proliferate after leaving the vessels is also a disputed point, and one which must at present be considered as unsettled.

The Tissues.—The effect of inflammation on the tissues of the affected part has been the subject of much discussion, and cannot yet be said to be finally settled. It was shown by Lister, in 1858, that in the area exposed to the action of an irritant every indication of life is in abeyance during the most acute stage of the resulting inflammation. The muscular coats of the arteries cease to show the irregular contractions seen in health, the pigment-cells in a frog's foot no longer exhibit their peculiar changes, and the blood flowing through the part behaves as if in contact with dead matter. He thus sums up the conclusions to which his observations led him: "It appears that the various physical and chemical agents which, when operating powerfully, extinguish the life of the constituents of the animal body, produce by a somewhat gentler action a condition bordering upon loss of vitality, but quite distinct from it, in which the tissues are, for the time being, incapacitated from discharging their wonted office, though retaining the faculty of returning afterwards, by virtue of their own inherent powers, to their former state of activity, provided the irritation have not been too severe or protracted." To this may be added that a still gentler action of the same agents, short of that necessary to produce the phenomena of inflammation, may stimulate the cells of the affected part to increased activity and proliferation. This theory alone was, however, inadequate to account for the appearance of a multitude of new cells in tissues still suffering from the effect of an injury, and yet the

microscope shows that this forms an essential part of acute inflammation. Consequently Lister's theory did not meet with the acceptance it deserved: and until the migration of the white corpuscles was finally established by Cohnheim in 1867, the process of inflammation, according to the Cellular Pathology of Virchow, was regarded as essentially one of increased nutritive and formative activity of the inflamed tissues. All the new cells were supposed to be formed by the rapid proliferation of the original elements of the affected tissues. The discovery of the migration of the white corpuscles, however, fully accounted for the appearance of the new cells in the inflamed area, without necessitating the improbable assumption, that injury to living tissues immediately increases their vital activity.

The changes which occur in the tissues as the result of inflammation have been observed both in vascular and non-vascular structures, during life and in preparations made after death. Amongst non-vascular structures the cornea may be taken as the type, and has most frequently been made the subject of investigation. The cornea is composed of a peculiar form of fibrous tissue arranged in strata, between which lie spaces of an irregular stellate form containing corpuscles corresponding with them in shape but not accurately filling them, thus leaving room for the passage of blood plasma and, under certain conditions, of white corpuscles. When the cornea of any animal is irritated by passing a fine silk thread through it, there forms, before many hours are past, an opaque spot extending for a short distance round the part injured. At the same time the vessels of the conjunctiva and of the sclerotic become engorged with blood. If the cornea be cut out and examined about sixteen to twenty-four hours after the injury, in the inflamed area, instead of the single stellate corpuscle naturally seen in each space, there will be found a group of rounded cells having all the appearances of white corpuscles. At one time it was thought that these were produced by proliferation of the corneal corpuscles. It has since been shown clearly that the appearance is really due to an accumulation of migrating cells in the space in which the corneal corpuscle lies, so as more or less completely to obscure the original cell. Whenever the original cell can be recognised, it shows no change. The behaviour of the corneal corpuscles under the influence of irritants was made the subject of a careful investigation by Senftleben. He applied to an extremely limited area in the centre of the cornea a solution of chloride of zinc of sufficient strength to kill the corpuscles with which it came directly in contact, without apparently damaging the fibrous tissue and especially the anterior homogeneous lamina. This was not followed by any dilatation of the peri-corneal vessels, and no cloudiness appeared round the injured area. The microscope showed no alteration in the uninjured corpuscles surrounding the damaged area and no migration of leucocytes into it. The explanation of this is that from the very small amount of the caustic applied, if any found its way by the lymph channels to the neighbourhood of the peri-corneal vessels, it arrived there so greatly diluted as not to produce any injurious effect on them, and thus no dilatation or migration took place. If the anterior homogeneous lamina was accidentally destroyed, the damaged tissue beneath, being exposed to the air, became septic, and the products of the septic change reaching the peri-corneal vessels damaged them, causing dilatation and migration into the cornea. The same effect could be produced by using a larger amount of the caustic or by applying it too near the corneal margin. Senftleben showed, therefore, that

unless the irritant act directly on the vessels surrounding the cornea no new cells appear in the damaged area, and nothing resembling proliferation of the corneal corpuscles takes place. His experiments further showed that about two days after the caustic had been applied, the corpuscles next to those which have been actually killed recover from the minor degree of injury to which they had been exposed, and commence to repair the damaged area. This is accomplished by spear-like processes of protoplasm which shoot out from the cells into the damaged area. A nucleus appears at the end of the process, the protoplasm surrounding it increases in quantity, and by a repetition of this process the loss of substance is repaired, the dead cells being absorbed by the advancing new growth. Nothing was observed to justify the belief that the corneal corpuscles under any circumstances divide and subdivide, thus forming a group of small round cells resembling a collection of migrated leucocytes. The importance of these observations on the question of repair is evident.

The observations of Senftleben have been fully confirmed by Leber in his exhaustive work on inflammation, published in 1891. Leber found that a species of aspergillus, the aspergillus fumigatus, when inoculated on the cornea grew readily, the mycelium of the fungus forcing its ways amongst the layers of the tissue. The effects of the growth of the fungus may be briefly summed up as follows: the inoculation having been made in the centre of the cornea, by the third day the part actually invaded by the fungus is evidently dead, forming an opaque spot around the seat of inoculation, and the margin of the cornea near the sclerotic vessels is cloudy. A day or two later three zones can be recognised: in the centre is the opaque spot formed by the dead corneal tissue invaded by the fungus; round this is a clear ring; and round this again a slightly elevated, yellowish-white opaque ring sharply defined towards the clear zone before mentioned, and gradually merging into the somewhat cloudy cornea between it and the sclerotic. In the next stage the yellow ring breaks down into pus, and the dead portion of the cornea with the fungus is cast off. At the same time inflammation of the conjunctiva and of the deeper structures of the eye usually took place; but this for the sake of clearness may be ignored. Miscroscopic examination shows the mycelium of the fungus infiltrating the corneal tissue in the opaque centre. In the transparent zone the corneal corpuscles cannot be recognised, and are evidently dead. In the ring of infiltration innumerable closely packed leucocytes conceal the corneal tissue. Leber explains the whole process thus: the fungus in its growth gives rise to an intensely irritating diffusible chemical product which kills the tissue it directly acts on; this causes the opaque necrotic spot in the centre. The transparent zone round the centre is also killed, but is not invaded by leucocytes, because it is impregnated by the chemical irritant in such a state of concentration as to repel the migrating cells. The chemical irritant becoming more dilute as it diffuses from the point of its production, by the time it reaches the vessels at the corneal margin damages them to the degree necessary to cause migration. Leber explains the movement of the corpuscles from the vessels towards the point of inoculation by the theory of chemiotaxis before mentioned (p. 161). He believes that the chemical substance generated in the centre when diluted at the margin of the cornea exerts an attractive influence on the leucocytes (positive chemiotaxis) which makes them crowd towards the damaged spot, but the same substance acting more intensely as the migrating cells approach the

centre, first arrests their movements and finally kills them, forming thus the purulent ring above mentioned.

The tongue of the toad has been examined by Dowdeswell with the object of ascertaining whether the fixed connective-tissue corpuscles take any part in the formation of the new cells which appear in inflammation. The details of his observations were published in the proceedings of the Royal Society in 1876, and he gives the following brief summary of the results he obtained: "So long as the circulation continued, no change whatever took place in the connective-tissue corpuscles, either as regards form or appearance, notwithstanding that the tissue of which they formed part was beset with innumerable emigrant colourless corpuscles, or (to use ordinary language) was infiltrated

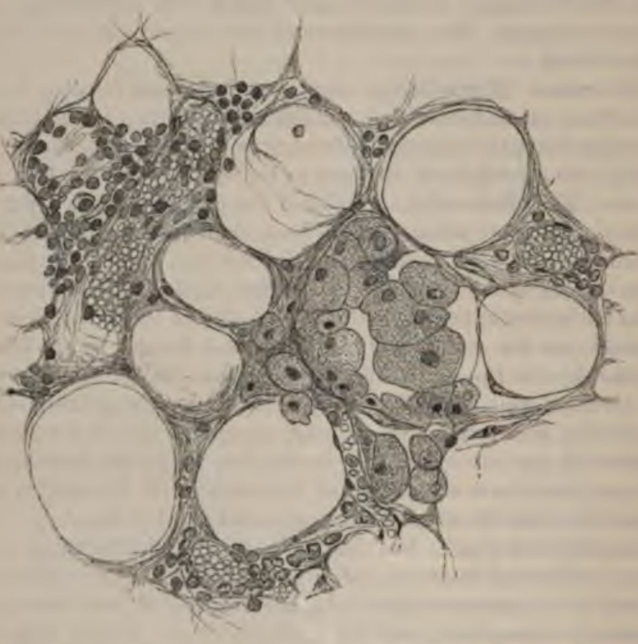

Fig. 85.—Inflamed Fat. Showing the fat cells with leucocytes between them. The migration is most abundant near a small vessel. Large granular cells derived from fat cells are seen.

with pus." In some cases the tongue was watched for eight or even nine days.

The conclusions drawn from these observations are confirmed by the miscroscopic examination of specimens of other inflamed tissues. In fat the leucocytes are found crowding between the fat cells, especially in the neighbourhood of small blood-vessels (Fig. 85); in muscle they accumulate between the fibres which themselves show no change, unless the process be very acute, and then the alteration is in the direction of degeneration, not of growth (Fig. 86). In bone the Haversian canals become filled with leucocytes; and should the process be of sufficient intensity and duration, the solid tissue disappears before the new cells, while at the same time the bone-corpuscles show no change unless one of degeneration. Thus acute inflammation in its early

stages, from whatever cause, and in whatever tissue it may arise, is always characterised histologically by essentially the same phenomena : a passive or degenerating condition of the original tissues with an abundant infiltration of new cells, which are white corpuscles migrated from the vessels, and possibly, the descendants of such corpuscles formed by division of the parent-cells after leaving the vessel.

The extent to which the process of cell-infiltration is carried depends upon the degree of damage done to the tissues by the irritant which has caused the inflammation. Supposing the damage done to be of a slight and temporary character, the tissues speedily recover from the condition of lowered vitality into which they have been thrown, the vessels recovering with the other parts. The circulation, therefore, returns to its normal state, and the exudation of plasma and migration of leucocytes cease. The liquid exudation drains away and such leucocytes as have found their way amongst the tissues find their way back by the lymphatics, or are absorbed by larger cells which may now appear on the scene. These larger cells also are motile and possess the properties of phagocytes, and from their size have been called *macrophages* or large phagocytes to distinguish them from the smaller cells already described, which have received the name of *microphages* or small phagocytes. The words microphages and macrophages are untranslated French, and not adapted to the English language. It is better to use the terms micro- and macro-phagocytes or large and small phagocytes. These larger cells are supposed to be formed by proliferation of the original cells of the part as they recover from the damage done to them by the irritant.

Fig. 86.—*f.* Fascia, œdematous and slightly infiltrated with leucocytes. *a.* Arteriole. *v.* Venule. *p.* Perimysium infiltrated with leucocytes. *n.* Nerve. *m.* Muscular Fibres, cut across.

It has before been pointed out that the same cause which, acting intensely, will cause the phenomena of inflammation, may in a milder form act as a stimulus to the tissues, causing increased nutritive activity and proliferation, just as the same chemical substance in a high degree of concentration arrests the movements of amœboid cells, while in a lower degree it stimulates their activity. It will be seen later on that, in chronic inflammations due to irritants of low intensity, cells of this type are abundantly present in all stages of the process. The sources of these larger phagocytes are supposed to be the connective-tissue corpuscles and the endothelial cells of the vessels and lymphatics.

It is possible that some of the larger cells may be formed by fusion of the smaller. The observations of Metchnikoff have clearly shown that this process occurs in many of the lower invertebrata when resisting the invasion of foreign organisms. Nothing of the kind appears to take place in acute

inflammation in the higher animals, but possibly the giant cells found in many forms of chronic inflammation may have their origin in this way.

The observations of Ballance and Sherrington, which will again be referred to in the Chapter on Wounds, confirm the above views. They showed that during the stage of traumatic inflammation resulting from a wound leucocytes (small phagocytes) appeared only in the injured area, and it was not till the inflammation had subsided, some eighteen hours after the infliction of the wound, that the large mobile cells (large phagocytes) made their appearance.

The functions of these larger cells are as follows. First, they complete the scavenging process which the leucocytes had commenced. The evidence of this is that they are frequently found enclosing in their substance fragments of tissue, red corpuscles, and micro-organisms, either dead or alive; and lastly the leucocytes, having performed their allotted duty, become as it were foreign bodies. Secondly, there seems to be no reason to doubt that these larger cells, derived from the original tissue of the part, are the active elements of repair in those cases in which the inflammatory process has been associated with actual destruction of tissue. As before stated, the latest observations tend more and more conclusively to prove that the migrated leucocytes take no part in the formation of new tissue.

The sequence of events in acute inflammation not accompanied by the formation of pus would therefore seem to be this:—The original cause of the process, the irritant, damages the tissues, temporarily suspending their vital activity, and possibly actually killing portions here and there. While the tissues are in this inert state they are invaded by the migrating leucocytes which, under favourable circumstances, proceed to remove any dead tissues, and perform the other functions above described. As the tissues recover, the original cell elements proliferate, and the cells thus formed also acting as phagocytes, complete the scavenging of the damaged area, consuming such migrated leucocytes as have not wandered away by the lymphatics, and then undertake the repair of the damaged tissues if necessary.

This process of recovery from inflammation, and restoration of the tissues to their normal condition without apparent change, is described as the termination of inflammation by resolution with *restitutio ad integrum.* The formation of scar-tissue in the place of any of the original tissues that may have perished will be described more fully in the Chapter on Repair.

Should the damage be more extensive, and of such severity that a small portion of the tissue is directly killed or injured to such a degree that the pressure of the accumulating cells and liquid exudation extinguishes such traces of vitality as may be left in it, it is evident that the simple process of resolution is impossible. The same will be the case when the cause of the inflammation is of a more persistent character, especially when the tissues are invaded by certain micro-organisms to be described in the Chapter on Suppuration. Under these circumstances, the exudation from the vessels and the migration of the leucocytes continue in the inflamed area until the leucocytes become heaped up and packed together amongst the damaged tissues, which now show signs of degeneration. The fibres of the connective tissue become swollen and softened, and finally disappear amongst the leucocytes; fat cells lose their contents, and in like manner are lost amongst the invading cells; muscular fibres lose their striation and become granular; the migrating cells penetrate within the sarcolemma, and the original tissue disappears before them; the

vessels in the same way become obliterated by pressure and are lost in the mass of new cells. In whatever part or tissue the change may be occurring the process is essentially the same—the original tissues degenerate and disintegrate, and their place is taken by a closely packed crowd of migrated leucocytes. Even at this stage it is possible for the process to stop should the cause of irritation cease to act. The leucocytes would then be removed in the way above described, the new cells derived from the original tissues would occupy the space, and recovery would take place with the formation of scar-tissue in the damaged area which would remain permanently through life.

Should the cause continue to act, the process will culminate in the formation of pus or suppuration. This condition is brought about by the softening of the intercellular substance in the centre of the group of closely packed leucocytes. The migrated cells themselves are cut off from proper nutrition by their mutual pressure, and are exposed to the injurious action of the micro-organisms which are almost invariably present in all cases of acute suppuration, and they consequently undergo degenerative changes and finally perish. They assume a more circular form; their protoplasm becomes filled with large highly refracting granules, some of which are fatty and soluble in ether, while others are albumenoid and can be cleared up by acetic acid. When thus cleared the cell, which now receives the name of a **pus-cell**, is found to contain a double or triple or sometimes quadruple nucleus. This was at one time considered a sign of degeneration, but, as before stated (p. 163), the greater number of the migrating leucocytes in their most active stage contain a similar multiple nucleus. The fluid which separates the pus-cells is formed partly by the softening of the intercellular substance which separated the heaped up leucocytes, and partly by the liquid exudation from the surrounding inflamed tissues soaking in amongst them. With this fluid come fresh wandering leucocytes; so that in the fluid drawn from an acute collection of pus, not only are the round dead pus-cells found, but with them many still showing faintly granular protoplasm and amœboid movements of the white blood corpuscle. The nature of pus, and the process by which a small collection spreads and forms an abscess, will be further discussed under Suppuration and Abscess.

If the process that has just been described should occur on a surface so that the pus finds a ready escape as soon as it is formed, we get another result of inflammation, which receives the name of **Ulceration.** The process of ulceration is, indeed, identical with that of the formation of a localised collection of pus. The original tissues are infiltrated by migrating cells which gradually destroy them and fill the space they formerly occupied; the new cells in their turn degenerate on the surface and are cast off as pus-cells. This will be further considered under Ulceration.

Inflammation has also been described as terminating in gangrene. This is most frequently the effect of some micro-organism invading the tissues, and giving rise in its growth to chemical products of so intensely irritating a character as to cause the death of the tissues upon which they act. At some distance from the invaded area the diluted products give rise to the phenomena of inflammation, but as the invading organisms advance the more concentrated virus kills the tissues. Another way in which the inflammatory process may end in gangrene is the arrest of the circulation by the pressure of the exuda-

tion. This is especially apt to occur when the circulation is feeble from partial obliteration, as the arteries from disease. It is also seen in frost-bite. Here the part is practically bloodless while frozen, but on being thawed becomes at once flooded with blood. If the tissues have been damaged to the degree necessary to give rise to inflammatory exudation, the pressure of the exudate, combined with the increased resistance from the retarded flow in the vessels, arrests the circulation, and the part which at first seemed likely to recover may become gangrenous (see Chapter XXX).

From the above description of the process of inflammation, it will be seen that the essential features are the retarded flow in the vessels, and the exudation of cells and plasma. The simple hyperæmia that occurs as the result of milder degrees of irritation cannot be looked upon as constituting a part of the true inflammation; and, on the other hand, when the stage of stasis is reached, inflammation must soon be brought to an end by the death of the affected part, unless the circulation be restored by the subsidence of the process. The process of acute inflammation is identical in all cases; it may vary in degree, in extent, and in termination according to the nature of the cause, and the vitality of the tissues on which the cause is acting, but the process is always the same. When, therefore, varieties of inflammation are spoken of, it must be borne in mind that the variations do not depend on differences in the essential nature of the process, in so far as the changes within the vessels and the exudation are concerned, but are the result of variations in the cause, and in the degree to which the vessels and other tissues are damaged by it.

Causes of Inflammation.—The causes of inflammation, like those of all other morbid processes, may be divided into **predisposing** and **exciting**.

The **Predisposing causes** may briefly be said to include every condition that tends to lower the vitality of the tissues, and thus to render them less able to resist external injurious influences. We now know that by far the most important of all external injurious influences causing inflammation is the invasion of the tissues by pathogenic micro-organisms, and it is a universal law throughout the animal and vegetable kingdom that feeble individuals most easily fall a prey to parasites of all kinds. The conditions necessary for healthy nutrition, and consequently for a high degree of vitality, are an abundant supply of healthy blood, connexion with a healthy nervous centre, periodical rest from functional activity, and at the same time a normal exercise of function. The influences disturbing these conditions may be Local or General.

Local Predisposing Causes.—The local conditions which interfere with the *quantity* of blood supplied to a part, have already been discussed under Local Anæmia and Congestion. In Passive Congestion, it will be remembered that, although the part habitually contains an excess of blood, there is a diminished interchange, and, consequently, the actual quantity supplied is less than natural. Both these local disturbances of circulation interfere with healthy nutrition, lower the vitality of the affected part, and thus render it prone to inflame from slight causes.

Loss of connexion with a healthy nerve-centre may be the result of destruction of the nerve-centre itself, or of injury to the nerves leading from the centre to the affected part. The best illustration of the effect of this condition is seen in contrasting paralysis of a limb from cerebral hæmorrhage, and paralysis

from acute spinal myelitis. In the former case, the paralysed limb is still in connexion with the healthy spinal cord, and ordinary care in avoiding pressure will prevent any formation of bed-sores. In the latter case, the slightest pressure or irritation causes inflammation, rapidly terminating in sloughing. Loss of connexion with a healthy nerve-centre is also seen not unfrequently in cases of division of the ulnar nerve, by which the little finger is completely cut off from its nervous supply. Under these circumstances, grave changes in nutrition are common, and inflammation is readily set up. That organs to which *insufficient rest* is given are prone to inflame, is, perhaps, best illustrated by the effects of excessive work on the eye ; and the converse, that *organs cut off from the performance of their natural function* suffer in nutrition, is seen in the fact that limbs condemned to inaction from disease of a joint are cold and waste, and that inflammation is set up in them by comparatively slight causes.

Though every tissue of the body is susceptible of inflammation, yet *some parts, from their anatomical conditions and structure, are more liable* to it than others. All cavities are exposed when wounded to the dangers of the accumulation of putrid or irritating fluids, and thus the serous and synovial membranes readily become affected with extensive spreading inflammation. Mucous and cutaneous surfaces, on the other hand, are protected by a strong and thick epithelium, and consequently require more powerful causes to produce inflammation.

When a part, *having once been the seat of inflammation*, has been left in a weakened or impaired state, it is more liable to a second attack, as it has less resisting power ; hence, also a subsequent attack may be induced by a less active exciting cause than that which at first started the process ; we see this in the inflammatory affections of the eyes and joints.

Constitutional Predisposing Causes.—That *old age* acts as a predisposing cause of inflammation, it is hardly necessary to say, the vitality of the tissues being greatly diminished in extreme age. *Anything that enfeebles the heart's action* to such a degree as to interfere with the supply of blood to the tissues, acts as a predisposing cause of inflammation. Thus operation wounds are more prone to become inflamed after great loss of blood, and in patients weakened by long fever or want of food. For healthy nutrition, it is not only necessary that there should be an abundant supply of blood, but *the blood that is supplied must be in a healthy condition.* The blood may be rendered impure by *the addition to it of some substance not normally present*, or by the *imperfect elimination of the products of normal tissue change*, or by the *deficiency of some of its normal constituents.* The most common and most important of the first class of conditions, is the habitual presence in the blood of an amount of *alcohol* in excess of that which can be easily eliminated or consumed. This is unfortunately the constant condition of but too many of the working classes, especially in large cities. A healthy country labourer, working hard in pure air, may consume and eliminate rapidly a large amount of alcohol ; but the city workman, engaged in a more or less sedentary occupation in an ill-ventilated workshop, is less able to get rid of the alcohol he takes ; while at the same time, the quantity he takes is probably greater, as his wages are higher and his opportunities for drinking more abundant. There can be no doubt that this condition of chronic alcoholism exerts a most prejudicial influence on all operations and diseases of the inhabitants of large

cities. *Habitual excess in eating* is almost as injurious as excessive drinking; for, as only a certain amount of food can be properly digested and assimilated, excess above this tends to interfere with healthy nutrition.

Chronic lead-, mercury-, and phosphorus-poisoning are other examples of the same class of causes. *The absorption of the chemical products of putrefaction from a wound*, as we shall see hereafter, causes severe fever; and the rapid wasting of the body which occurs in this condition is clear evidence of the serious disturbance of nutrition that it gives rise to. It is the experience of all Surgeons that wounds made during septic fever are exceptionally liable to inflammation, and generally do badly.

Saccharine diabetes, which of all conditions exerts the most injurious influence on wounds and injuries, may perhaps be most conveniently classed under this heading; as also *jaundice* when due to simple obstruction of the bile ducts.

Amongst the causes of *impurity of blood from insufficient elimination of the normal products of tissue change*, Bright's disease is the most important. *Gout* also is perhaps most properly included under this heading. Both these conditions are powerful predisposing causes of inflammation. Diseases of the lungs and liver act in the same way.

Amongst conditions due to the *insufficiency of some of the normal constituents of the blood* is anæmia, such as is commonly seen in young women: and here also might be classed those conditions due to a deficient supply of the necessary elements of food, such as scurvy, from want of fresh, green vegetables, and the general condition of mal-nutrition brought about by deficiency of oxygen in the air habitually breathed and want of food in general.

Lastly, there is the constitutional condition known as *scrofula*, in which inflammation tends to occur under the influence of exciting causes less in degree than those which affect healthy subjects; but the essential nature of this condition is still but imperfectly known.

Exciting Causes of Inflammation.—Inflammation is usually said to be the immediate result of *local* "*irritation*," and the causes of inflammation are commonly spoken of as "*irritants*." Irritation properly means excitement (*irrito*, I excite); and consequently the physiologists speak of tissues possessing "irritability," when a healthy manifestation of functional activity can be induced by the application of external stimuli. At the time when inflammation was believed to be an exaggeration of the normal activity of the inflamed tissues, the cause that produced it was very naturally spoken of as an irritant. Now that acute inflammation is known to be essentially a condition of diminished vital activity of the tissues in the inflamed area, the term may give rise to some misconception unless the sense in which it is used be clearly understood; at the same time, its use in the sense of something causing inflammation has become so firmly fixed, not only in surgical but in popular language, that it would be most inconvenient to try to change it. An irritant may, therefore, be defined as something tending to damage the tissues on which it acts, and temporarily to lower their vitality; if acting more feebly, it frequently acts as a stimulus, calling forth manifestations of normal function; if more severely or persistently, it causes the death of the tissue upon which it acts. Heat may be given as an example. If the skin be exposed to a temperature of about 100° F., simple hyperæmia results with increase of normal function, as shown by perspiration; boiling water applied merely for a second causes

inflammation ; and a red hot iron would, of course, give rise to immediate death of the part it touched. The *effect produced* by an irritant will depend first, upon the *intensity* of the irritant ; and secondly, upon *the powers of resistance of the tissues* on which it acts : thus, in the feeble tissues of a limb the arteries of which are so diseased as to bring the supply of blood below the normal standard, inflammation is readily induced by slight causes. It has already been stated that insufficient supply of blood acts as a powerful predisposing cause of inflammation ; the complete arrest of the circulation, if continued for a sufficient length of time, acts as a direct exciting cause. This was shown by Cohnheim in his well-known experiments on the tongue of the frog and on the ear of the rabbit. If the ear of the rabbit be emptied of blood, and a temporary ligature applied at its base, the effect produced is proportional to the time during which the ear is kept bloodless ; if this be a few hours only, temporary hyperæmia alone results, with perhaps slight swelling ; if about twelve hours, the ear becomes greatly swollen, there is retarded flow in the vessels with abundant inflammatory exudation, and the tissues become infiltrated with migrating white blood-corpuscles ; if the ear be kept bloodless till its vitality is lost, the blood cannot enter it, the corpuscles immediately choking the vessels and blocking them as in inflammatory stasis, so that any flow is impossible. Thus any degree of inflammation can be produced at will by varying the time during which the ear is kept bloodless. Cohnheim showed also that after the ear has been bloodless for a time sufficient in some degree to lower its vitality, slight injuries cause a higher degree of inflammation than in a healthy ear. This experiment is sometimes unintentionally performed on the human subject. Some years ago a patient came under my care, whose whole arm had been accidentally rendered bloodless by the application of an apparatus for the treatment of fracture of the clavicle. At first, when the bandages were removed, the limb seemed hopelessly dead ; but after a short time it was evident that, although its vitality was reduced to the lowest possible degree, it was not absolutely destroyed, for the blood began slowly to find its way even to the finger-tips, but with this all the phenomena of acute inflammation were developed. The limb became swollen, red and tense to such an extent that the circulation became again arrested by the pressure of the exudation, and gangrene set in, necessitating amputation at the shoulder-joint. On making incisions into the amputated limb, a most abundant inflammatory exudation, like thin pus, streamed from the subcutaneous tissues and muscles. The same phenomena are observed in strangulated hernia. It is a well-known fact that in complete strangulation, even when the gut has been cut off from the circulation for many hours, no inflammatory exudation is found on its surface when the sac is opened in the operation ; but should the patient die shortly after reduction, the gut is found to be covered with a thick layer of inflammatory exudation. Here, as in the rabbit's ear, the phenomena of inflammation do not manifest themselves till the circulation is re-established in the strangulated part.

Irritants, that is to say, injurious influences acting as causes of inflammation, may be divided into six groups : **Mechanical, Physical, Chemical, Organised, Functional,** and **Nervous.**

1. **Mechanical Irritants** may be thus subdivided :—(*a*) *Direct mechanical violence*, as in wounds, bruises, fractures of bones, &c. (*b*) *Movement*, which is a frequent cause of persistence of inflammation, as in inflamed joints, but is

seldom an exciting cause of the original mischief. (*c*) *Friction*, as in blisters on the feet and hands. (*d*) *Tension.* Tension acts both as a primary and a secondary cause of inflammation; a tight stitch, pent-up discharges in a wound, or obstruction of the duct of a gland, are all familiar examples of tension acting primarily as a cause of inflammation. As a secondary cause it comes into play very frequently to a greater or lesser degree, causing a persistence of the process till it is in some way relieved. The pressure of the exudation prevents the return of vitality in the parts injured by the primary cause of the inflammation, and thus delays or prevents recovery. In the treatment of inflammation we shall see that many of the means adopted have for their object the prevention of tension and pressure from excessive exudation. In an acute abscess the tension produced by the fluid takes an important part in maintaining the process of suppuration, which subsides more or less completely as soon as the pus is let out.

2. **Physical.**—Under this heading are included *heat*, *cold* and *electricity*. The effects of the two first are too familiar to require further explanation. Electricity acts as a cause of inflammation only when it gives rise to decomposition of the tissues by electrolysis.

In *gout* the local inflammation is probably usually determined by some slight injury, but the actual cause is the excess of uric acid in the blood, and urate of soda is deposited in the affected part. We have here an example of an acute inflammation caused by a chemical substance formed in the body itself. It has been shown by Gautier and others that alkaloidal substances, to which he gave the name of *leucomaines*, are formed by the decomposition of albuminous bodies during the normal metabolic processes taking place in the tissues. These bodies are poisonous, like the ptomaines formed in putrefaction, and it is possible, though there is no evidence to prove it, that the local formation and accumulation of such substances may be the cause of some inflammations apparently arising spontaneously.

3. **Chemical.**—All strong *acids* and *alkalies* and innumerable *salts*, such as corrosive sublimate, chloride of zinc, &c., act as irritants when applied to the tissues. Numerous *natural products of the vegetable kingdom*, such as croton oil, mustard, &c., and some *animal products*, such as cantharides and the poison of various venomous reptiles and insects, act more or less powerfully as exciting causes of inflammation.

The most important, however, of all the class of irritants in surgical practice are the chemical products of the fermentative processes set up by the growth of micro-organisms in various albuminous fluids. These processes may be divided into two great classes, first, the **simple septic processes** or **ordinary putrefaction**, in which the micro-organisms grow only in dead matter, such as serous fluids accumulated in a wound or portions of dead tissue, the effect on the living tissues being caused by the chemical products of putrefaction becoming diffused in them; and secondly, those more complicated processes in which the micro-organisms invade the living tissues and act as genuine parasites. It was to the irritation caused by the micro-organisms and their products that the inflammation and suppuration which formerly accompanied almost all large wounds were due, and the modern improvement in surgery is almost entirely due to our more accurate knowledge of the conditions under which micro-organisms can develop, and the means by which their growth can be prevented. It is necessary, therefore, here briefly to consider the nature and

necessary conditions of these fermentative processes, taking as the type the ordinary putrefaction of animal matter.

Decomposition or putrefaction of animal matter is a process of fermentation, the essential conditions of which are, 1, *the presence of dead animal matter*; 2, *a sufficient supply of oxygen*; 3, *the presence of water*; 4, *the maintenance of a certain temperature*; and 5, *the ferment*. These may be considered more in detail.

1. **The presence of dead animal matter.**—We have already seen that in acute inflammation a coagulable exudation takes place; when this coagulates it entangles in the meshes of the fibrin a vast number of white corpuscles which have migrated from the vessels, thus forming the so-called inflammatory lymph, while the serum either flows away by the lymphatics or accumulates in the spaces natural to the part. In the case of an open wound the exudation accumulates on the surface and forms, as will afterwards be seen, the first bond of union; while the serum drains away, unless, from any imperfection in the treatment, it is allowed to accumulate in the cavity of the wound. In compound fractures and wounds opening the natural cavities of the body, perfect drainage is not always possible. The exudation is composed to so large an extent of living cells that it may be looked upon as living tissue, and consequently incapable of undergoing putrefaction. It is otherwise with the serum, which is dead matter. Extravasated blood, either in the spaces of the areolar tissue, as in a bad bruise, or in the cavity of a wound or other injury, as in a compound fracture, is also decomposable, although less readily than the serum which is squeezed out of the clot as it contracts. The pus contained in an abscess, or the urine in a distended bladder, are other examples of putrescible animal matter in the living body.

2. **A sufficient supply of oxygen.**—The tissues themselves, and the blood circulating in them, contain quite enough oxygen for the process of putrefaction. This is shown by the fact that offensive decomposition frequently takes place in wounds from which, immediately after the injury, the air has been excluded by some external application, such as styptic colloid, collodion, or the like.

3. **The presence of water.**—All living tissues and the fluids of the body contain enough water to putrefy readily, but the proportion is not that most favourable to the process. The more watery an exudation, the more readily will it decompose.

4. **The maintenance of a certain temperature.**—Experience shows that the temperature of the human body is one highly favourable to the process of putrefaction.

5. **The presence of the ferment.**—The four previous conditions of putrefaction have been universally recognised for a long time past; but the necessity for the action of a ferment as the starting-point of the process is amongst the modern discoveries of science. Ferments are of two kinds, organised and non-organised. The *organised ferments* are microscopic vegetable organisms belonging to the class of fungi; the *non-organised* are chemical substances, such as diastase, pepsin, ptyalin, &c., which give rise to definite chemical changes in the special substance upon which they act. The process of putrefaction is a fermentation, dependent on the presence of vegetable organisms belonging to the lowest class of fungi.

In all putrefying animal fluids these organisms are found in great abund-

ance. They are very commonly spoken of collectively as "bacteria," though the name "bacterium" belongs more properly to one special form. The term **Schizomycetes** (σχίζω, I cleave, and μύκης, a fungus), or **fission-fungi**, is employed for the whole order. The fission-fungi are divided into classes according to their forms, the chief being the Micrococci, or round organisms; Bacilli, or rod-shaped organisms; and Spirilla, or corkscrew-shaped organisms. All these organisms are composed of a mass of protoplasm, without a nucleus, enclosed in a delicate cell-wall. They multiply chiefly by fission, but some varieties grow from spores.

Micrococci are round or slightly oval organisms, varying from $\frac{1}{25000}$ to $\frac{1}{10000}$ of an inch in diameter, and are often recognisable only by the highest powers of the microscope. They occur singly or grouped in pairs (diplococcus), chains (strepto-coccus), or clusters (staphylo-coccus). When in colonies they are often bound together by a homogeneous substance termed "Zooglœa." There is no reason to believe that they ever lengthen out into rod-shaped organisms, as they can be cultivated for many generations in various media without changing their form. They are non-motile, and are reproduced chiefly by fission, but under certain circumstances some members of a colony or a whole generation are said to assume the characters of spores, at the same time undergoing little or no change in their external appearance. This would explain the persistence of the virus of some of those diseases which are supposed to be due to micrococci.

The **rod-shaped organisms** are generally divided into **bacteria** and **bacilli**. **Bacteria** are minute fungi having the form of very short cylinders with rounded ends. They are often so short that they are more correctly described as oval than as rod-shaped. They exhibit active movements, but occasionally a group become united together by a jellylike substance or zooglœa, which limits or arrests their motion. Their movements are in many varieties produced by a flagellum at one or both ends. This can only be recognised by the very highest powers of the microscope. Bacteria multiply by fission, and spore formation has not been demonstrated.

Bacilli are cylindrical in form, like bacteria, but their length is greater in proportion to their breadth. They vary greatly in size, some forms not being more than $\frac{1}{20000}$ of an inch in length, while others may reach $\frac{1}{1250}$. In form some varieties are straight, others slightly curved. They are mostly non-motile, but some kinds are provided with a flagellum and are capable of movement. All multiply by fission, and the separate segments may remain attached to each other, forming long jointed filaments. Most, if not all, also propagate themselves by spores under special conditions. The spore first appears in the substance of the bacillus as a bright spot, which gradually increases in size, consuming a certain proportion of the protoplasm in so doing, till it may form a slight thickening of the rod at the point at which it lies. Several spores commonly form in each rod. Finally, the remaining protoplasm perishes, the sheath gives way, and the spores become free. The spores stain feebly or not at all with most aniline dyes, and are thus recognised without difficulty.

The term **leptothrix** is applied to very long thread-like organisms. These are constantly present in the mouth.

Spirilla are spiral filaments, possessing active powers of movement. They are believed to form spores like bacilli. When the corkscrew-like turns are

most markedly developed the curved organism is termed a **vibrio**. This classification is extremely imperfect, but in the present state of our knowledge, neither botanists, bacteriologists, nor pathologists seem to be able to agree on any definite arrangement of these organisms. It is probable that the same organism under different conditions of growth may vary considerably in form, and this adds another difficulty in the way of accurate classification.

All these organisms being destitute of chlorophyl, consume oxygen in their growth and give off carbon dioxide. Some require free oxygen, and are for that reason termed "*aërobic*" by Pasteur; others derive their oxygen from the organic compounds in which they grow, and cannot develop in the presence of free oxygen, and are then termed "*anaërobic;*" others again are aërobic or anaërobic, according to the circumstances in which they are placed. All require an abundant supply of water, without which they cannot grow.

All these micro-organisms are killed by boiling the liquid in which they are growing, and most by a temperature of 140° F. Freezing is also fatal to many forms, and few survive prolonged drying. All chemical substances classed as antiseptics, such as carbolic acid, salicylic acid, perchloride of mercury, &c., when in solutions of sufficient strength, destroy their vitality; in weaker solutions they inhibit their growth.

The spores of the bacilli, however, exhibit the most remarkable resisting powers. They are not affected by boiling unless it be prolonged for some minutes; they are uninjured by drying or freezing, and only the most powerful antiseptic solutions will destroy their vitality. None, however, are supposed to be capable of withstanding a dry heat of 250° F. maintained for one hour.

Among these various fungi some are capable of developing in dead matter only; others can attack living tissues and grow amongst them like true parasites. The former are termed *septic organisms*, *saprophytes*, or *carrion fungi;* the latter *parasitic*, or *pathogenic fungi*. It is with the septic fungi only that we have to deal at the present moment.

Each fungus which acts as a ferment is supposed to set up a special process accompanied by the formation of definite chemical compounds, but this subject is at present very imperfectly worked out. In putrid animal fluids many forms of fungi, belonging to all the classes above mentioned—micrococci, bacteria, bacilli, vibriones and spirilla—are always met with, and the products of ordinary putrefaction are consequently extremely numerous and complex. It is impossible to name a special organism for every product, and there is no doubt that one may give rise to many. The chief products of putrefaction of animal matter are the following:—*Gases:* Nitrogen, Carburetted hydrogen, Hydrogen sulphide, Hydrogen phosphide, Ammonia, Ammonium carbonate. *Acids:* Formic, Acetic, Butyric, Propionic; Ammonium sulphide. Tyrosin and Leucin are also present. In addition to these, substances chemically allied to Alkaloids, and known as Ptomaines, are developed. Amongst the most important of these are neuridine, saprine, cadaverine and putrescine, which are almost constantly found in the putrefaction of proteids. These substances are locally irritating to the tissues, and when absorbed are intensely poisonous. Bergmann also isolated a crystalline substance, to which he gave the name of Sepsin, and which he believed to be the special toxic agent in septic fluids; but the poisonous and irritating properties of putrid matter are not due to a single substance, and in the present state of our knowledge it is more conve-

nient to use the general term "products of putrefaction" than to attempt to specify any special septic poison.

As a general rule, it may be stated that when gas is abundantly developed in a putrid animal substance this is due to the presence of bacteria, most micrococci and bacilli not giving rise to any appreciable amount of gaseous products. In ordinary fetid putrefaction one organism constantly present is the *bacterium termo*. This is a short actively-moving organism, rather oval than rodlike in shape. It requires abundant water for its growth, and is easily destroyed by drying and by all antiseptics. When micrococci alone exist in an albuminous fluid there may be a sour smell, but there is not the ordinary fetid odour of putrefaction. In the practical prevention of fermentative changes in animal fluids, as in the antiseptic treatment of wounds, it is found much easier to exclude bacteria than micrococci, as these latter seem to grow under conditions which destroy the former.

It has been proved by experiment that septic or non-pathogenic organisms cannot develop amongst living tissues, and should they enter the blood-stream they speedily perish. The local and constitutional effects they produce are solely by means of the chemical products formed in the dead matter in which they are growing.

That these organisms are the actual cause of putrefaction of dead animal matter, and that they are derived from pre-existing organisms of the same kind, is universally acknowledged. It is impossible here to discuss the evidence by which this has been proved. So far as our present purpose is concerned, it may be sufficient to state that putrescible fluids, such as urine, milk, or hydrocele serum, if collected in vessels which have been heated to a temperature sufficient to destroy all living organisms, and with due precautions to avoid contamination from other sources, may be kept for an indefinite time without undergoing any chemical change or developing any fungoid growths. Air may be freely admitted to them without producing any sign of putrefaction if it has previously been deprived by filtration of any solid particles floating in it, or if it has been submitted to a sufficiently high temperature, or to the action of some chemical substance capable of destroying the vitality of any living organism. It is evident, therefore, that putrefaction is not merely a chemical process caused by the presénce of gases of the air. If a fluid or solid cultivating medium which has thus been kept unchanged for weeks, or even months, be exposed to unpurified air for a few seconds, and then again protected, no result may follow; if for a few minutes, microscopic fungi are almost sure to make their appearance; but it is by no means certain that the organism that appears will be one of the fission-fungi, or that the fermentation that follows will be ordinary fetid putrefaction. More commonly moulds of various kinds appear, especially if the air be dry. If the exposure be prolonged, or the air very damp, the probability of the appearance of micrococci, bacteria or bacilli will be much greater. The conclusion drawn from this is that the spores of moulds are always floating in the air in considerable numbers, but that fission-fungi are much less abundant, although often present. The same result may be obtained by cultivating the dust of a room on nutritive gelatine or on a boiled potato. In a series of cultivations bacteria and micrococci appear occasionally, while the moulds constantly develop. By exposing fluids or other cultivating media to the air for fixed periods of time, it can be clearly shown that all forms of organisms exist much more abund-

antly in the air of houses than in that of the open country, and more in great cities than smaller towns (see p. 8).

The number and nature of the organisms which develop after exposure of artificial cultivating media to the air have been found by Miquel to vary considerably with the composition of the fluids used. Thus, he states that a measured quantity of air containing 200 organisms capable of developing on a weak neutralised solution of Liebig's extract of meat might only contain one capable of growing in a neutralised infusion of hay. This he terms a difference of "sensitiveness" or "putrescibility." It would seem that pus, blood-serum, and more especially blood, have a low degree of putrescibility, and may be exposed to unpurified air with much less risk of decomposition than was at first supposed, the great majority of air-borne organisms being incapable of developing in albuminous fluids of so high a degree of concentration. Although by applying the results of experiments made with highly sensitive fluids directly to serum and blood an exaggerated idea of the putrescibility of these fluids was at one time entertained, it cannot be denied that organisms may be present in the air which are capable of growing and setting up fermentative changes even in those concentrated albuminous fluids, and it would seem wiser not to run into the opposite extreme of ignoring air-borne organisms altogether as a source of infection of the discharges of wounds or abscesses. In our damp climate especially it is certain that the ordinary septic bacteria are usually present in the dust of the air.

If instead of exposing the putrescible fluid to the air a small quantity of unpurified water be added, bacteria make their appearance with almost absolute certainty, and ordinary fetid putrefaction most commonly follows. From this it is to be concluded that water is the special habitat of the ordinary bacteria of putrefaction. However much, therefore, we may feel justified in relaxing some of the precautions which were at first recommended for the exclusion of the dust of the air from wounds, we cannot be too careful to avoid the use of water which has not been rendered innocuous by boiling or by the admixture of some efficient antiseptic.

It having been clearly proved therefore that these micro-organisms are the cause of the process of putrefaction, by what means can they gain access to the putrescible matter in wounds, abscesses or cavities containing animal fluids?

Only two modes of entrance need be considered: 1. *The organisms might be conceived to enter by the lungs and alimentary canal*, and thus find their way into the circulation and enter the dead matter from within. That this mode of entrance does not occur with the ordinary saprophytes or organisms of putrefaction, is evident from the fact that subcutaneous accumulations of putrescible fluids, such as pus and serum, or portions of dead tissue, such as a part of an organ cut off from its blood supply by a simple embolus, do not undergo putrefaction. It has, moreover, been shown by experiment that the fungi which cause ordinary putrefaction, even if injected into the blood-stream, speedily perish, and thus no such organisms are present in the tissues of a healthy animal. That other forms of organisms can enter in this way must be acknowledged, for in all acute infective inflammations and acute abscesses, microscopic organisms are found at the seat of disease even when there is no external wound.

2. *The bacteria are admitted directly from without.* Of this there can be no

doubt. We have already seen that they may be present in the air, although not in such numbers as was at one time supposed; they are more abundant, however, in the neighbourhood of decomposing matter, as in a ward containing many wounds the discharges of which are in a state of decomposition. They are carried into wounds, abscesses, or other cavities by the Surgeon's hands, by instruments, and more especially by water, unless some means are adopted to destroy them; and they are abundantly present in the unpurified skin of the human body. Still it cannot be too clearly understood that even when they are carried into the body, or into a wound, the ordinary bacteria of putrefaction can do no harm unless they come in contact with dead matter. They speedily perish in the blood, and they exert no influence on living tissues. Amongst living tissues we must class the coagulable lymph that covers the surface of a wound; while the serum is dead matter. In a wound or abscess cavity, therefore, which is perfectly drained, the bacteria soon perish; and were perfect drainage always possible, we need not fear their presence. This is not always possible, however; and consequently it becomes in most cases a matter of great importance to exclude all micro-organisms from wounds or abscesses, and to destroy any which may have found admission.

4. **Organised Irritants or Parasites.**—This class of irritants includes those organisms which have the power of growing as true parasites in the living tissues of the animal body. Among them must be included certain animal parasites, such as the itch insect (acarus scabiei), the chigoe (pulex penetrans), the trichina spiralis, &c., which bury themselves in the living tissues and there excite a greater or less degree of inflammation. These are of little importance however, compared to the vegetable organisms which are the direct cause of many forms of inflammation, as erysipelas, malignant pustule, and other specific affections. It is probable that the inflammation set up by these parasitic fungi is the result of the formation of irritating chemical products by a process analogous to putrefaction and fermentation; still it is important to make a very clear distinction between the effects of simple putrefaction and the inflammation caused by these more potent organisms. In simple putrefaction the irritating material is formed as the result of changes occurring in the dead matter only, and may be regarded as being developed outside the body; and, when it gives rise to spreading inflammation, this is due merely to the chemical products of the process soaking into the surrounding tissues, just as any soluble irritating salt, such as corrosive sublimate, might do; but the irritant does not increase in quantity amongst the living tissues, and its effects are directly proportional to the quantity developed locally. There is, in other words, no *infection* of the surrounding tissues. With the organisms of which we are now speaking, however, the case is different, for they grow into the surrounding living tissues, and excite inflammation as they spread: they enter the circulation by the lymph-stream or by the blood-vessels, and may multiply in the circulating blood, giving rise to changes in its composition incompatible with life, or they may lodge in distant parts, and there grow and set up local inflammation similar to that at the original seat of disease. From their direct power of exciting unhealthy processes, these organisms are spoken of as "pathogenic fungi." They cause a *true infection both locally amongst the tissues adjoining the part first affected, and generally in the whole system.* The poison multiplies in the body of the affected individual, and the effects it produces are not directly proportional to the quantity of the original

dose inoculated. To inflammations arising from this cause the term "**infective**" is applied.

The pathogenic organisms belong to the same orders and classes as the saprophytes just described. They belong chiefly to the orders micrococcus and bacillus (see p. 178), but pathogenic bacteria are also met with, as in emphysematous gangrene. The individual species will be described with the diseases with which they are associated (Anthrax, Glanders, Tubercle, Erysipelas, &c.).

The theory of infective inflammations generally received at the present time is that under certain conditions these parasitic fungi take up their abode in a part of the body frequently already damaged, as in a wound or a centre of suppuration, and then, while growing, give rise to a process of fermentation in the fluids of the part, the products of which are irritating locally, and poisonous if absorbed into the system. Some forms are capable of multiplying in the blood and thus affecting the whole system. They are then supposed to act partly by lodging in minute vessels and exciting at the point at which they are arrested a process of inflammation similar to that in the original seat of disease, partly by forming poisonous products by their action on the fluids of the blood, and partly, like true parasites, by absorbing oxygen and other nutriment to the detriment of the tissues of the body.

The **true infective inflammations** are therefore due to the accidental introduction of a poison or virus which possesses the power of increasing in quantity in the living tissues. The effect produced is, therefore, quite irrespective of the size of the original wound or starting-point of the inflammation. Thus the prick of a needle in sewing up a body after a post-mortem examination may start an inflammation extending through the whole arm. In an infective process of this kind the virus exists abundantly in the products of the inflammation, that is to say, in the inflammatory exudation, and if by any means these products are transferred from one part of the body to another, they set up a similar unhealthy inflammation wherever they may lodge; and, in like manner, a similar inflammation may be started in another individual by inoculation of the exudation. The local spread of the inflammation is due to the irritating inflammatory products which contain the ferment-like poison finding their way into the lymph-spaces of the surrounding tissues. An infective inflammation may be limited to one part of the body, and spread merely by local infection, as in spreading gangrene and phlegmonous erysipelas; or the poison may be taken up by the lymphatics, and cause inflammation similar in character to the original process in the nearest lymphatic glands without infecting the system generally, as in soft chancre and some forms of dissecting wound; or it may be carried throughout the body by means of broken-down clots from the veins of the primary seat of disease, giving rise to local inflammation wherever the fragments of clot may lodge, as in some forms of pyæmia; or lastly, the poison may enter the blood and multiply in it, giving rise to a general infective process, as in septic infection, malignant pustule (splenic fever), or syphilis. The term "infective" is, therefore, applied only to those conditions in which the poison multiplies in the living tissues of the body; when the infection merely spreads locally without affecting the whole system, the result is called a **local infective inflammation**; when the poison enters the system and multiplies throughout it, presumably in the blood, the affection is spoken of as a **general infective**

process. Before it can be accepted as proved that any organism is the actual cause of a specific form of inflammation or infective process, the following conditions laid down by Koch must be fulfilled :

1. In every case of the disease in question submitted to examination a micro-organism possessing morphological characters sufficiently definite for its recognition must be found in the affected tissues or the blood.

2. The micro-organism must be cultivated out of the body in a suitable medium in such a manner as to prevent its accidental contamination by any other organism. The cultivation must be carried on to many generations by successively inoculating fresh portions of the cultivating medium with the growth, until it may be assumed that no trace remains of the blood or other animal matter with which the first culture was necessarily contaminated.

3. The pure culture of the organism must then be inoculated in an animal susceptible to the disease in question, with the result of producing the specific affection.

4. Lastly, the characteristic organism must again be found in the tissues or blood of the animal in which the disease has been artificially induced.

All these conditions have been fulfilled in a large number of diseases of animals, such as anthrax, glanders, swine-plague, spreading gangrene in mice, &c. &c. In three diseases the two last conditions have been fulfilled in the human subject. Fehleisen has successfully inoculated the micrococcus of erysipelas, Bokai that of gonorrhœa, and Garré the staphylococcus of boils.

On the other hand, in some undoubtedly infective inflammations, as, for example, syphilis and soft chancres, no specific organism has yet been definitely proved to be the actual cause.

The action of the pathogenic fungi, the mode of invasion of the body, and the resistance offered to their attacks, will again be referred to in the chapter on infective diseases in general.

Admitting to the fullest possible extent the influence of pathogenic fungi in the causation of infective processes in wounds and elsewhere, experience teaches us that the hygienic surroundings of the patient exert an influence of the greatest importance in their development.

Putrefaction is, as we all know, a process quite independent of hygienic conditions : a dead body will become putrid in the fresh air of the country just as surely as in a crowded city, and in the same way pent-up discharges will putrefy in a palace as certainly as in the foulest dwelling of the poor. Under the best hygienic conditions, if putrid discharges accumulate in a wound or in the cavity of an opened abscess, local inflammation and suppuration are excited, and union of the wound or closing of the abscess-cavity is delayed. The local and constitutional disturbance will, however, be less than when the patient is exposed to bad hygienic conditions ; for the tissues being better nourished and of higher vitality, will suffer less from the irritation of the septic matter, and the septic poison entering the system will be more readily eliminated. True infective processes in wounds are rare, even when the discharges are decomposing, unless at the same time the patient is exposed to unhealthy surroundings. In private practice erysipelas was uncommon, pyæmia was rarely met with, and hospital gangrene unknown, even when no special means were adopted to prevent decomposition of the discharges. If, however, a number of patients whose wounds are treated

without antiseptics, be crowded together, as in the case of the wounded after a battle, even if it be in a building which has never before been used for such a purpose, infective processes are certain to manifest themselves. How it is that infective processes characterised by the presence of a specific virus capable of transference from one individual to another, make their appearance under unfavourable hygienic conditions is still far from being fully understood. It has yet to be determined whether each form of infective inflammation is due to a specific organism constantly present in the air or in water and ready to attack the patient when the unhealthy surroundings to which he is exposed, or other causes of mal-nutrition, such as prolonged wound-fever, or constitutional disease have reduced his strength so far as to make it possible for the parasitic fungi to invade his body; or whether simple, non-pathogenic organisms may, by growing in the discharge of a wound rendered unhealthy by putrefaction, develop a virulence they did not before possess, and so become capable of invading the living tissues. Koch and other observers have shown that, however the organisms may acquire their virulent properties, and whatever may be their origin, when a characteristic organism has been found associated with a distinct form of infective inflammation, it can be transferred from animal to animal by inoculation and even cultivated artificially in proper media outside the body; and that, generation after generation, it reproduces itself in the same form, and when inoculated produces the same variety of infective process. It has also been shown by Pasteur and many others that the virulence of an organism may be so reduced as almost to be lost by cultivating it in unsuitable media, or under unfavourable conditions, or by passing it through animals little susceptible to its influence, and that by opposite means its full potency may be restored to it. This fact certainly favours the second theory as to the development of pathogenic fungi.

When a specific organism has once found its way into a hospital ward, it is evident that, unless wounds be specially protected, infection of one from another may easily occur through the air, the danger being diminished proportionally to the separation of the patients and the freedom of admission of pure air. The poison can also undoubtedly be carried from one wound to another by dirty instruments, or sponges, or by the Surgeon's hands or clothes.

Many pathogenic organisms, besides being inoculable externally, can undoubtedly enter the blood-stream by the lungs or alimentary canal, and reach the local seat of inflammation from within. Microscopic organisms are found in all acute abscesses and in many infective inflammations in which there is no open wound; and we must, therefore, admit that they have found their way in by the lungs or alimentary canal. We have before seen that this mode of entrance cannot be admitted in the case of the ordinary bacteria of decomposition; it is equally certain that it cannot be denied in the case of the organisms of infective inflammations. Experience, however, teaches us that it is not by any means common in local injuries; for the total absence of organisms from a wound can be assured, almost with certainty, by means calculated to protect it from external contamination only.

Lastly, it remains to be discussed, what is the relation of ordinary putrefaction to the development of infective inflammations?

Ordinary putrefaction acts both generally and locally. The invasion of the living tissues by an infective process may be regarded as a struggle between

the virus and the tissues, and anything that lowers the vitality of the latter will favour the former. The putrefying discharges irritate the parts with which they come in contact and directly lower their vitality, as is evidenced by the inflammation set up; and they thus favour the invasion of the tissues by the pathogenic bacteria. This would only be in harmony with the well-known fact common to the animal and vegetable kingdoms, that feeble individuals, or feeble parts of an individual, are most readily invaded by parasitic fungi.

The contrast between a wound healing aseptically by the first intention and one in which septic suppuration is taking place on the third day is very marked. In the former case, tissues in a full state of vitality are separated merely by a thin layer of plastic exudation so largely composed of living cells that it may fairly be regarded as living tissue; in the latter, the tissues for some distance on each side are lowered in their vitality by the irritation of the products of putrefaction, and are separated from each other by a fluid which forms one of the most suitable media for the development of any true infective virus that may find admission to it.

Generally decomposition of the discharges acts in two ways: first, it depresses the patient by the fever caused by the absorption of the products of putrefaction, and thus renders him more liable to suffer from any general infective process; and secondly, it is a well-recognised fact that the emanations from putrid matter exert an injurious influence on the health of those who inhale them—in fact, the removal of putrescible matter, or the prevention of its decomposition, forms one of the most essential features of domestic and hospital hygiene.

No greater mistake could be made, however, than to imagine that with the prevention of putrefaction all necessary hygienic precautions are ended. As before pointed out (p. 9), the products of respiration foul the air and exert a depressing influence on those who breathe it to a degree that cannot be overrated; and too great attention cannot be paid to ventilation and the avoidance of overcrowding.

5. **Functional Irritation.**—Every tissue requires a periodic rest from functional activity for healthy nutrition, but it is very seldom that the want of such rest can act as more than a predisposing cause of inflammation. Occasionally, however, inflammations of joints or of the eyes seem to be directly dependent on excessive exercise of function.

6. **Nervous Irritants.**—The part played by the nervous system in the direct causation of inflammation has always been a question involved in considerable obscurity. That inflammation can take place, and readily does so, in a part completely cut off from any connection with the central nervous system has been proved by numerous experiments; in fact, such a condition has already been described as a predisposing cause of the process. The clinical phenomena usually cited as examples of inflammation arising from injurious influences transmitted to the affected part by means of the nervous system, are the so-called sympathetic inflammations of the eye and of the testicle, and herpes zoster. It is a well-known fact that, when one eye is affected by destructive inflammation following a wound, unless the diseased globe be early removed, the other eye is liable also to become inflamed. The latest observations, however, tend to prove that the inflammation in such cases in reality spreads from one eye to the other by direct extension along the

optic nerve to the commissure. Gonorrhœal inflammation of the testicle is in like manner now usually regarded as a direct extension of the inflammation by means of the vas deferens. Herpes zoster is an inflammation of the skin arising from no known external cause, and usually limited to the area supplied by a single sensory nerve or nerve-root. In this case we can scarcely doubt that the cause, whatever it may be, acts in some way through the nerve. Although it is difficult to prove that the nerves take, ordinarily, any active part in the causation of inflammation, there is no doubt they exert an important influence on its progress by their controlling influence on the circulation. Irritation of a sensory nerve is known to cause dilatation of the vessels in the whole area supplied by the nerve; and the painful stretching of the nerves in inflammatory swelling, by causing such a dilatation, increases the blood pressure in the inflamed part, and consequently augments the exudation and aggravates the tension.

Varieties of Inflammation.—John Hunter divided inflammation first into two kinds, viz. the healthy and the unhealthy. "The healthy," he says, "probably consists only of one kind, not being divisible but into its different stages." "The unhealthy admits of vast variety," "according to the kind of health in the constitution or part." He also divided inflammation according to its effects into "the adhesive, the suppurative, and the ulcerative." The term "**adhesive inflammation**" has for nearly one hundred years occupied so important a place in surgical language, that it will be better here briefly to define it. Adhesive inflammation is the result of an irritant acting temporarily with such a degree of severity as to cause exudation of almost pure blood-plasma and migration of the corpuscles, with coágulation of the fibrin in or on the injured tissues. At the same time, the damage done by the irritant must not be of such severity as to cause the death of any appreciable amount of tissue; nor must it continue to act after it has produced the degree of impaired vitality in the vessels necessary to cause the exudation. To take an example: the damage done by the passage of a sharp knife through healthy living tissues is sufficient to develop in the area acted upon the stage of inflammation characterised by retardation of the blood-stream, exudation of a coagulable fluid and migration of white corpuscles. The exudation coagulates on the injured surface and in the spaces of the injured tissue, the fibrin and the white corpuscles remain, forming what is known as "inflammatory lymph," and the serum partly drains away externally and partly returns by the lymphatics to the circulation. This inflammatory lymph is the material of adhesion in adhesive inflammation, and if two surfaces covered with it are brought in contact, they adhere to each other. The knife can of course act only while cutting the tissues; the moment the cut is made the cause ceases, the effect only remaining. If no new cause of irritation comes into play (such as the friction of the surfaces on each other, or the presence of foreign bodies, or chemical irritants as putrid matter, persistently-acting, powerful antiseptics, &c.) the effect gradually subsides, the injured tissues recover their vitality, exudation ceases, the coagulated inflammatory lymph remaining glues the surfaces to each other, and adhesive inflammation is said to have taken place. Should some persistent source of irritation, such as one of those above-mentioned, be brought into play in the wound, the exudation does not cease so long as the cause of irritation is acting; consequently, such "inflammatory lymph" as may have been formed by the coagulation of the exudation,

becomes softened by the continuous flow from the vessels, and infiltrated by innumerable migrating corpuscles till it breaks up and flows away as pus, and "**suppurative inflammation**" is said to have been developed. At the same time that this is taking place, the tissues which form the surfaces of the wound, being unable in consequence of the presence of the irritant to return to their normal state of vitality, become infiltrated by innumerable wandering cells which fill all the spaces and press upon the original tissues, finally absorbing them and occupying their place; thus the surface of the wound becomes converted into a layer of closely packed leucocytes, the superficial cells of which are continually degenerating, becoming loosened, and floating away in the discharge as pus-cells. Beneath this layer the original cells of the tissue begin to proliferate, being protected by it from the direct action of the irritant, and thus we get a new tissue developed from the old, in which new vessels develop, forming granulation tissue, the superficial cells of which, when they become exposed to the irritant, break down, and take part in the formation of pus. If, in consequence of a higher degree of irritation, the new growth from the original cells is very limited or altogether absent, and thus destruction exceeds formation, the process gradually extends into surrounding tissues; a new layer becomes infiltrated by migrating cells, pressed upon and absorbed, and its place occupied by the crowded leucocytes, which in their turn break down and are thrown off, and thus a progressive destruction of tissue takes place. This process is called **ulceration**; or, in the language of Hunter, "**ulcerative inflammation**" is said to be occurring. If the irritation be still more severe, the migrating cells may perish before they have formed a distinct layer: and, instead of the process just described, in which the original tissues are first replaced by the leucocytes, which then break down and melt away as pus, the tissues may themselves undergo direct disintegration, and the products of this change will form part of the discharge, which under these circumstances will contain shreds of the broken-down tissues and be less rich in leucocytes, or, in other words, in pus-cells. Thus in rapid ulceration the discharge may be scarcely puriform, but composed of serous fluid with the *débris* of the perishing tissues. Lastly, if the irritation be still more intense and rapid in its action, or the original vitality of the affected part so low that it is incapable of resisting even mild injurious influences, the death of the original tissue will take place with such rapidity that the dead mass will be visible to the naked eye, forming a **slough**, and the process is then spoken of as **gangrenous inflammation**. Thus there is no sharp line to be drawn anywhere between simple adhesive and gangrenous inflammation. One form merges into another, and the effect produced is proportional to the degree of irritation and to the power of the tissues to resist the injurious action of the irritant.

Inflammations are also frequently divided, according to their real or supposed causes, into **Traumatic**, when arising from injury, **Strumous**, **Rheumatic**, **Gouty**, **Syphilitic**, &c. Finally, when the cause cannot be discovered, they are often called **Idiopathic**.

Perhaps, however, the most important distinction is into **Simple localised inflammations** and **Spreading inflammations**. The simple localised inflammations are due to causes which act usually only on a limited area and in a temporary manner. A spreading inflammation is one in which the cause is of such a nature as to be continuously developed either in contact with or in

the substance of the affected tissues, and which, consequently, extends more or less widely beyond the area first affected.

The simple traumatic inflammation resulting from the action of a sharp knife on the tissues is the best example of simple localised inflammation. The effect is accurately limited to the area injured, and unless some new cause be introduced the process cannot extend. Should the discharges become putrid, the inflammation will extend as far as the chemical products soak into the surrounding tissues, but no further (p. 182). There is no infection, and the process is still local, though extending more widely from the point of original injury; but should the wound become infected by a pathogenic organism, a true spreading or infective inflammation is developed, the limits of which it is impossible to predict (p. 183).

Inflammation is also divided into **acute** and **chronic**, according to its intensity and duration. The symptoms, terminations and effects that have already been described are those which characterise the more acute and ordinary forms of the process. Chronic inflammation will be described in a subsequent part of this chapter. So-called *catarrhal* inflammation will also be described separately.

Phlegmonous is a term applied to an acute inflammation in which the cardinal symptoms—redness, swelling, heat and pain—are well marked.

Inflammations of organs are also divided into **interstitial** and **parenchymatous.** By the former term is meant that the process is either limited to or most marked in the interstitial fibrous tissue of the organ; by the latter that the special structures, as the epithelium of glands, are implicated in the morbid process.

Croupous inflammation is a term applied to the process when it is accompanied by a firmly coagulated fibrinous exudation, either on the surface of a membrane or in the spaces of its tissue.

The Local Signs of Inflammation may be referred to five heads: viz. 1. *Alteration in Colour;* 2. *Alteration in Size;* 3. *Modification of Sensation;* 4. *Increase of Temperature;* and 5. *Modification of Function of the Part Affected.* The first four of these, redness, swelling, heat and pain (*Rubor et Tumor cum Calore et Dolore:* Celsus), have been described from time immemorial as the cardinal symptoms of inflammation. Certain of these conditions may occur separately, or two or more may be associated together without the existence of inflammation, but it is the peculiar grouping together of them all that most distinctly characterises this pathological condition. The relative intensity of these changes varies greatly, according to the tissue which is the seat of the inflammation; thus, in mucous membranes and in the skin, the alteration in colour is most marked; in areolar tissue, the change in size always attracts special attention; and when a fibrous tissue is inflamed, its sensibility becomes greatly increased. It must not be forgotten, however, that one or another of these signs may be absent, especially pain and heat.

1. **Alteration of Colour** is one of the earliest and most striking signs of inflammation; parts that are naturally perfectly pale, as the conjunctiva, assuming the most vivid red colour when inflamed. The redness is due to the dilatation of the vessels and the accumulation of red corpuscles, and in very acute inflammations, partly to the escape of the red corpuscles from the vessels. The redness of acute inflammation varies with the intensity of the process. Where there is merely determination of blood it disappears completely and readily on pressure with the finger, returning again with the

greatest possible rapidity the moment the finger is removed. When the circulation is retarded, the redness disappears and returns more slowly, and a few red spots may remain unaltered by pressure. These are either points at which the process has reached the stage of stasis, or at which red corpuscles have escaped from the distended capillaries into the surrounding tissues. The tint of the redness varies also according to the activity of the circulation through the inflamed area. When the flow through the vessel is free and rapid, the inflamed surface assumes a bright scarlet tint; but where there is a tendency to stagnation, either from the feeble state of the patient's circulation, or from the inflammation having approached the stage of stasis, the colour becomes a dull purple. The change from bright red to dusky purple is well seen in phlegmonous erysipelas, when the circulation through the inflamed skin becomes impeded, and gangrene is threatening. After acute inflammation it is frequently weeks or even months before the vessels regain their normal tone, and until this has taken place, a certain degree of redness will remain.

Redness is not, however, a constant appearance in inflammation. In non-vascular parts it occurs in the nearest vascular tissues, and not in the part actually suffering from inflammation. In inflammation of the iris the dilated vessels are concealed by the pigment, and the change of tint is from the natural brownish or bluish colour to a greyish or greenish, in consequence of a yellow tinge given to the aqueous humour by the serous exudation into it.

The redness of inflammation disappears more or less completely after death. Where there has been escape of the coloured corpuscles red spots remain, giving rise to the appearance known as "punctiform redness." In septicæmia, pyæmia, and malignant forms of the acute specific diseases, the red corpuscles break up in the blood before death, staining the serum and the lining membrane of the heart and great vessels. A similar staining always takes place after decomposition has set in. It is perfectly uniform, without spots or branching lines, and must be carefully distinguished from the redness of inflammation. Increased redness develops also in the most dependent parts after death from gravitation of blood before coagulation. Thus a coil of intestine hanging down in the cavity of the pelvis may become redder than the rest of the gut, and may be wrongly thought to be inflamed.

2. **Alteration in size.**—The swelling of inflamed tissues is due to the increased afflux of blood and to the exudation from the vessels.

The swelling varies greatly in different localities. It is greatest in loose textures, and least in those which are firm and dense. Thus, for instance, in inflammation of the areolar tissue of the scrotum, the swelling is much greater than in inflammation of the testis. Inflammation of the conjunctiva occasions great swelling, that of the sclerotic but little. In dense hard structures, such as bone and ligament, there is, of course, very little swelling. If inflammation become chronic, the swelling may terminate in permanent hypertrophy or thickening, as will hereafter be described.

So much of the swelling as is due to hyperæmia disappears after death; that resulting from exudation remains unchanged, and is an important post-mortem sign of inflammation.

3. **Modification of Sensibility.**—There is in inflammation always more p[illegible] which is owing partly to increased sensibility of the nerves, possibly [illegible] of blood, but chiefly to the pressure and stretching exercised [illegible]minal branches by the dilated blood-vessels, and by the inflam-

matory exudation. In inflammation due to chemical irritants, such as the products of putrefaction, it is probably in part due to the direct action of the irritant on the nerve endings.

That the pressure of the dilated blood-vessels really is a cause of the pain in inflammation is shown by the relief derived from the elevation of an inflamed part. In inflammation of the testicle this is especially marked, as the veins leading from that gland are valveless, and in the erect position the weight of a column of blood, two feet or more in length, acts upon the vessels and tends to increase the intra-vascular pressure. We frequently find, therefore, that the patient is altogether free from pain while lying flat on his back; but the moment he rises into the erect position the characteristic sickening, aching, and throbbing sensations return.

In inflammation of organs of special sense, instead of actual pain there may be some alteration in the special nervous sensibility of the diseased organ. When the eye is inflamed, subjective flashes of light may be seen; when the ear is diseased, there may be noises of various kinds.

In inflammation of the bladder, there is a constant desire to expel urine; and in inflammation of the rectum, there are frequent attempts at defæcation.

Pain is one of the most prominent symptoms of inflammation, and its existence serves a useful purpose by preventing the patient from using or moving the inflamed part. The intensity of the pain depends more upon the structure affected than on the violence of the inflammation, being, as a rule, greater in proportion as the tissue affected is incapable of yielding to the pressure exercised on it by the dilated vessels and the inflammatory exudation. Hence, in general, the severity of the pain is in inverse ratio to the swelling of the part. Thus, the pain of inflamed bone or fibrous tissue is excessive; that of areolar tissue trifling, and in erysipelas of the scalp most pain is experienced in the ears. In some forms of inflammation pain can scarcely be said to be present; thus, in septic peritonitis there may be little or none.

The character of pain varies according to the seat of inflammation. When mucous membranes suffer, it is often of an itching or burning character, as in conjunctivitis; when the serous membranes of the chest or abdomen are attacked, it is lancinating or stabbing; it is aching in osteitis; throbbing when pus is about to form; sickening when the testis is affected. Inflammatory pain is always increased by pressure; when it is produced principally by pressure, the part is said to be *tender*. This tenderness is of great service from a diagnostic point of view; it may be elicited by direct pressure upon the part, as by squeezing an inflamed testis, or by pressing two surfaces together, as in an inflamed joint. In inflammatory pain, especially of osseous and fibrous tissues, there is very commonly nocturnal exacerbation.

It is important to bear in mind that the pain in inflammation is often referred to other parts supplied by the same nerve as that implicated in the inflamed area. These reflected pains are usually referred to the terminal branches of the nerve. Thus, in hip disease, in which the branch of the obturator to the joint is implicated, the pain is often referred to the inner side of the knee, where the terminal branches of that nerve communicate with the internal cutaneous and saphenous nerves. In deep-seated inflammation of the eye the patient often suffers excruciating pain along the branches of the fifth nerve over the whole side of the head and face. These reflected pains are often of the greatest importance in the diagnosis of deep-seated inflammations.

4. **The Temperature** of an external part of the body when inflamed rises above its normal standard, but not above that of the blood in the left ventricle. In inflammation of internal organs, the temperature rises only as the general heat of the body is elevated by the inflammatory fever. John Hunter originally pointed out this fact; he found, in a case of hydrocele, that a thermometer inserted into the tunica vaginalis stood at 92° F. before inflammation had been excited in the sac, and at 98·75° F. after it had been set up. The conclusion to be drawn from these facts is, that the local increase of temperature in inflammation, when it occurs, is due to the flow of a larger quantity of blood through the part and not to a development of heat in the part itself, dependent on increased tissue-change. This view has been confirmed by the most recent observations, carried out with the greatest exactitude by the thermo-electric apparatus. The opposite view has been maintained by J. Simon, O. Weber and others. The facts that a thermo-electric apparatus has been found necessary to measure the variations in heat, and that observers of the greatest eminence have held opposite views, are sufficient to show that, even supposing heat to be developed locally in inflammation, it cannot be in sufficient quantity to have any appreciable effect on the general temperature of the body or on the local processes in the inflamed part. To the patient, however, there appears to be a real rise of temperature; as Travers truly remarks, "the nerves measure the sensation and not the degree of heat." In many cases the sensation of the patient is that of *burning* in the part, although the actual rise in temperature may be but trifling. This is owing to the exalted sensibility of the nerves.

5. **Modification of Function** invariably occurs in inflammation, and furnishes important local symptoms. The *Functional Activity* of an organ is decreased or abolished during acute inflammation. As an acute inflammation is always the result of some injurious influence which lowers the vitality of the affected part, it is evident that this must be the case. The condition is exaggerated in some cases by the pain, the disordered circulation, and the pressure from exudation. An inflamed muscle is impaired in its power of contraction, and an inflamed gland either ceases to secrete or yields a secretion altered in composition by the admixture of products of inflammation. The *natural use* of a part is often interfered with; thus the bladder can contain no urine, the eye can bear no light, nor can a joint be moved, when inflamed. The normal processes of *nutrition* are either modified or arrested; hence softening, degeneration, or even death of the affected tissues, are common accompaniments of inflammation.

CONSTITUTIONAL SYMPTOMS.—The severity of the constitutional symptoms will depend on the intensity, the extent, and the nature of the inflammation, on the previous state of the patient's health, and on the vital importance of the part affected. Thus a moderate degree of inflammation in a part of no vital importance, as the skin, and occasioned by an external cause, as an abrasion, gives rise to no appreciable constitutional disturbance; but if the part affected be of great importance, as the larynx or the kidney, the general symptoms are proportionally severe. The nature of the inflammation and of its cause exerts more influence than any other condition in the constitutional effects. Simple traumatic inflammation gives rise to symptoms of slight severity and short duration; while septic and infective inflammations often prove fatal by the disturbance they cause in the system rather than by their local effects.

Inflammatory or Symptomatic Fever.—The constitutional disturbance in inflammation always assumes the form of fever. Inflammatory fever is a consequence of the local affection. It is thus clearly distinguished from the so-called essential fevers, in which the febrile condition either occurs without any local inflammation or precedes the local affection by a distinct interval, as in the acute specific diseases. The one essential symptom of all forms of fever is elevation of the temperature of the body, or pyrexia; without this, fever cannot be said to be present.

In health, a balance is maintained between heat-production (thermo-genesis) and heat-loss (thermo-lysis), and thus the constant normal temperature is maintained (thermo-taxis). Heat-production takes place chiefly in the muscles and large glandular organs; heat-loss takes place chiefly by radiation and evaporation of water from the skin (70 to 80 per cent.), and by evaporation from the lungs, and warming the air respired (15 to 16 per cent.). Both the production and the discharge of heat are under the control of nerve-centres, the exact situation of which is not determined, but they probably lie above the medulla. Heat-regulation must necessarily also be controlled by nerve-centres. All these centres must also be in some way associated with the vaso-motor centres, as variations in the circulation, in the heat-producing and heat-discharging organs, accompany all variations in heat-production and loss. In fever these various mechanisms are deranged in such a way as to cause an elevation of the bodily temperature, but the heat-regulation, though deranged, is not abolished. The normal morning fall and evening rise persist in almost all febrile conditions, but the variations are greater. Another evidence of the derangement of the heat-regulating mechanism is that external changes of temperature, especially cold, produce a much greater variation in the bodily heat than in health.

It is evident that an elevation of the bodily temperature would result from increased heat-production without a compensating increase of heat-discharge, or from diminished discharge, production remaining the same; and many other combinations may be imagined. There have consequently been many theories of fever, which it is impossible to discuss here, but the following facts may be given as generally agreed upon at the present time.

In fever there is an increased production of heat, not merely a diminished loss. The actual amount of heat produced may or may not be greater than might occur in the same individual in health, on full diet and in active exercise, but it is always out of proportion to the conditions under which the patient is placed as to diet and exercise during the febrile state. That increased heat-production takes place is proved by the evidence of excessive tissue-change, such as the disappearance of fat, the wasting of the muscles, the increased excretion of urea and carbonic acid, and by calorimetric observations on animals in which the febrile state has been artificially induced. There is also a considerable increase in the loss of water by the lungs, and often from the skin. In some conditions, such as the rigor following operations on the genito-urinary organs, the contraction of the cutaneous vessels may act as one of the causes of the elevation of temperature by diminishing the loss of heat from the skin; but this is merely an accident and not an essential feature of fever.

The increased production of heat takes place throughout the body, being most active in muscles and glandular viscera. It is certainly not developed to any appreciable extent in the inflamed area, for, as before stated, the latest

observations tend to prove that there is no elevation of temperature above that of the blood in the part actually inflamed; and, even supposing these observations to be erroneous, it is evident, from the difficulty in detecting it, that the heat developed in the area of inflammation must be extremely small in amount and quite insufficient to account for the elevation of the temperature of the whole body by several degrees. The fever is not caused by the pain usually accompanying inflammation; for experiments have shown that irritation of sensory nerves tends rather to lower the temperature by causing a certain degree of shock.

It has been clearly proved by experiment that fever can be induced by injecting into the blood-stream noxious materials of various kinds. Substances which, when thus injected, cause fever are said to possess "*pyrogenic properties.*" Amongst the substances possessing marked pyrogenic properties is the lymph returning from an inflamed area, charged, as it is, with the products of the destructive changes which are going on in the part. It has already been stated how largely the flow of lymph is increased during acute inflammation, ounces returning from the diseased part where drachms return from the corresponding sound part. It is evident, therefore, that the effect produced on the blood during inflammation may be very considerable, and will vary with the extent of the inflammation and the amount of local destructive tissue-change which is going on. One substance, which must frequently be present in considerable quantities in the lymph returning from an inflamed area, viz. the so-called "fibrin-ferment," possesses very powerful pyrogenic properties. This, it will be remembered, is one of the elements concerned in the formation of fibrin. It is supposed to be yielded up by the white corpuscles which become disintegrated during the process of clotting of the blood. It is found in considerable excess in the serum which can be squeezed out of a freshly formed coagulum; and as coagulation of an inflammatory exudation is the same process as coagulation of the blood, it may reasonably be concluded that fibrin-ferment exists in considerable amount in the serous fluid which drains away from a surface or an area in which an inflammatory exudation is coagulating, to form the so-called "plastic lymph." Köhler, Edelberg, Birk, and others investigated the effects of the injection of the free ferment into the circulation of animals, and found that in very large doses it causes coagulation of the blood in the right side of the heart, and death. In smaller doses it gives rise to a febrile disturbance closely resembling that produced by the injection of putrid substances. The fever varies in intensity with the quantity of the ferment injected: and, if this be sufficiently small, the animal recovers without serious symptoms after an elevation of temperature of short duration. There seems to be no reason to doubt the accuracy of these observations. Large numbers of white corpuscles are believed to be disintegrated in the process of coagulation, either of pure blood or of an inflammatory exudation. The theory of "*ferment-poisoning*" may thus, in part at least, account for the fever that always accompanies simple inflammations and large wounds, even with aseptic discharges, and that occasionally follows extensive extravasations of blood. Only under very exceptional circumstances in the human subject could the dose of the ferment be sufficient to cause the more severe symptoms that have been experimentally produced in animals; but possibly the explanation of some cases of death from cardiac thrombosis, that is to say, ante-mortem coagulation of the blood in the right side of the

heart and the pulmonary artery, may be found in the presence of an excess of free fibrin-ferment. The fever produced by the entrance into the circulation of the products of healthy inflammation is the only form to which the term "inflammatory" can properly be applied; but practically, in a very large proportion of cases, the pure inflammatory fever is complicated by a disturbance resulting from the admixture of the products of putrefaction or of specific infective processes with those of the simple inflammation. In fact the products of decomposition are amongst the most powerful of all pyrogenic substances, and we have already seen that locally they are amongst the most potent causes of inflammation. The products of putrefaction of animal substances are so varied and uncertain in their chemical composition that it is better not to attempt to specify them. This much, however, may be said to be proved, that, in the case of ordinary putrefaction, the chemical products, and not the microscopic organisms which invariably accompany the process, are the real exciters both of the local inflammation and of the febrile disturbance. The organisms of simple putrefaction, as before stated, can live only on dead matter; and, if they happen to enter the circulation, they speedily perish, unlike the true parasitic or pathogenic organisms which accompany many infective processes and grow and flourish in the living tissues or blood. The effect produced by the absorption of the products of putrefaction is, therefore, proportional to the dose; the poison has no power of multiplying in the system and, if the dose be not too great, it is speedily eliminated without serious consequences. If the dose be excessive, it gives rise to a train of symptoms which will be described in the chapter on septicæmia. The products of putrefaction are absorbed with great readiness from a raw surface or the charred surface left by a burn; but it is said that the ease with which they are taken up is greatly diminished by the application of some chemical caustics, especially chloride of zinc. Healthy granulation-tissue forms an efficient barrier to absorption under ordinary conditions (presumably from its possessing no lymphatics); but at slight degrees of pressure the pyrogenic substance passes readily through it. Thus in a large wound, such as an amputation, if there is perfect drainage and no decomposition, the febrile disturbance is very slight and of brief duration, ceasing by the third day at the latest; if there is decomposition of the discharges the fever is higher, and reaches its maximum by the third day, subsiding gradually as the granulations spring up and form a barrier against further absorption; if with decomposition there is insufficient drainage and the wound be of sufficient size, the patient may receive such a dose of the products of putrefaction as to die poisoned—a condition which will be described in the chapter on Septicæmia. If after the granulations have sprung up and fever has ceased, an accumulation of putrid matter takes place in the cavity of the wound, and there is such a want of drainage that the fluid is pent up at some degree of pressure, the fever and local inflammation will return; but should the drainage be made perfect, they will again cease. It is the fever due to these two causes—the products of destructive tissue-change and exudation in simple inflammation, and the pyrogenic products of putrefaction in septic inflammations—that is commonly spoken of as "surgical or traumatic fever;" but these terms should properly be limited to the former of these conditions as being a fever inseparable from any large wound or injury, even when subcutaneous, and the term "septic fever" should be employed for the latter.

Fever is also a constant accompaniment of acute infective inflammations: that is to say, of those conditions in which a virus is present, which has been proved in most cases to be a micro-organism, which multiplies in the living body, either locally, as in local spreading or infective inflammation, or generally, after entering the blood from the original centre of infection, as in many forms of septicæmia and in pyæmia, malignant pustule, &c. The fever in these cases is due, in part at least, to the admixture of the chemical products of the growth of the organism with the blood. That these substances are capable of exciting fever has been proved by the injection of the products of their growth on artificial cultivating media.

Fever may also be caused by the presence in the blood of chemical substances generated in the body itself. The most simple example of this is the fever that accompanies an attack of gout.

It has before been pointed out that heat-production, heat-discharge, and heat-regulation are under the control of the central nervous system. Two theories have been held with regard to those fevers which are due to the admixture of pyrogenic substances with the blood: the first is that the pyrogenic substance acts directly on all the tissues of the body, giving rise to increased tissue-change with development of heat; and the second is that the impure blood circulating through the brain disturbs the heat-controlling centre, and thus indirectly acts on the tissues. The latter is the view generally accepted at the present time.

We are yet very far from fully understanding the exact nature of fever; but what we do know is of immense practical value. We know that in the majority of cases in which fever forms a serious feature in surgical practice, it is due to the entrance into the circulation of noxious materials generated locally, and that in its treatment our first object must be to arrest the formation of the pyrogenic material by local means. For example, in an acute abscess a fluid containing the products of destructive tissue-changes is pent up in a cavity at some degree of pressure, and a certain proportion of the pyrogenic material it contains is constantly finding its way into the circulation. Open the abscess and cut off the supply and the fever at once subsides; but if, for want of drainage, the cavity fills again and its contents be allowed to decompose, the fever will return more severely than before, as putrid matter is more powerfully pyrogenic than the products of simple inflammation; open up the cavity and drain it, and again the fever will subside; but possibly, supposing the patient to be exposed to infection in an unhealthy and overcrowded hospital, a virus, capable of multiplying in the surrounding tissues, and perhaps of increasing, like a ferment, in the blood itself, may find its way from without into the abscess cavity and thence infect the whole system. Under such circumstances, the mere local treatment will no longer be able to arrest the febrile disturbance; and, unless the patient have sufficient vitality to resist its effects, a fatal result must follow.

Symptoms of Fever in General.—Although inflammatory fever or pyrexia presents clinically many varieties, certain symptoms are common to all. The first and most important of these is *elevation of temperature*, as shown by the thermometer. All temperatures above 99·5° F. (37·5° C.) must be considered as indicating fever. The fever is considered slight unless the thermometer rises above 100·5° F. (38° C.); up to about 102·5° F. (39° C.) it is considered moderate; from 102·5° F. (39° C.) to 105° F. (40·5° C.) it is

spoken of as high fever, and above that point the term *hyperpyrexia* is applied to it. Few patients recover from any febrile condition in which the thermometer rises above 107° F. (41·6° C.).

The temperature is usually taken in the axilla, but occasionally the mouth or rectum is used instead. In taking the temperature in the mouth, the bulb of the thermometer must be put under the tongue and the lips kept firmly closed for three minutes. In the mouth and rectum the temperatures registered are about half a degree higher than those in the axilla. The temperature in all inflammatory fevers shows the morning fall and evening rise, common to nearly all febrile conditions.

Many febrile conditions arising in surgical practice, especially those connected with acute suppuration and some forms of blood-poisoning, are ushered in by *chilliness*, *shivering*, or *a rigor*. A well-marked **rigor** commences with a sensation of cold, accompanied by great nervous depression and anxiety, often amounting to fear, on the part of the patient. The feeling of cold is so intense that the patient covers himself with hot clothing and shivers beneath a heap of blankets till his teeth chatter. If during this *cold stage* of the rigor the temperature be taken in the mouth, it will be found to be greatly above normal, often as high as 105° F. If the temperature had been taken before the rigor commenced it would have been found that the rise in the thermometer began some time before the sensation of chilliness set in. During the cold stage the face is pale and the whole surface of the body is more or less blanched. The surface temperature of the extremities is not raised and may be subnormal. This is due to the contraction of the arteries of the skin, which is the essential feature of the cold stage of a rigor. The bloodless condition of the skin thus induced is the cause of the sensation of cold, and by limiting the loss of heat from the surface it takes some part in producing the rapid elevation of temperature. After a time varying from ten to twenty minutes or even more, the contraction of the cutaneous arteries yields, and a corresponding dilatation follows. The surface of the body becomes red, the face is flushed, the skin becomes moist, and gradually a profuse perspiration sets in—sufficient, in many cases, to soak the sheets of the bed. During this *hot stage* of the rigor, the patient feels intensely hot, although the thermometer shows that the temperature is rapidly falling, the loss of heat from evaporation of the perspiration being necessarily very great. In half an hour or more the sweating ceases and the whole rigor is over, leaving the patient weak and exhausted.

In all forms of fever there is *increased frequency of the heart's beat*. This is, as a rule, proportional to the elevation of the temperature and to the degree of weakness of the patient. The respiration is increased in frequency, usually in the same proportion as the pulse. The face is generally flushed, but by no means always so.

Another feature common to all forms of fever is *emaciation and loss of strength*. The increased production of heat must be regarded as work, and consequently during febrile disturbances the patient may be expending force as truly as if he were carrying weights or climbing mountains. At the same time, his appetite is lessened and his powers of digestion and assimilation of food reduced. The rapid exhaustion and emaciation of many fevers is therefore not to be wondered at.

Thirst is always one of the most prominent symptoms, and the *appetite* is

diminished or lost. In almost all high febrile conditions there is *dryness of the skin;* for, although in fever there is an increased elimination of water, this takes place chiefly by the lungs. The mucous membrane of the alimentary canal also secretes less than natural, and to this cause are due the *dry tongue,* the accumulations on the teeth and lips or *sordes,* and the *constipation* so commonly met with in fever.

In all febrile conditions there is a feeling of lassitude or weariness, and a marked disinclination to bodily or mental exertion. Headache is a common symptom. In the earlier stages of very acute febrile disturbance, there may be *delirium* of a violent form: in the later stages, when the strength is becoming exhausted, wandering or muttering delirium is common. The patient's sleep is disturbed, he is restless at night, and delirium is more often met with at that time than during the day.

Fever is said to *terminate* by **Lysis**, when the symptoms gradually subside; and by **Crisis**, when the fall of temperature is sudden. In the latter case, it is often accompanied by a "*critical evacuation,*" as a free flow of urine containing a large quantity of lithates, a profuse perspiration, or a watery discharge from the bowels.

Severe fever of any kind always leaves the patient weak and anæmic, in consequence of an excessive destruction of the red corpuscles. In the most extreme forms of septic fever, this takes place to such an extent that the plasma becomes stained during life by the colouring matter of the disintegrating corpuscles.

The **urine** in all febrile conditions is scanty and high-coloured. It contains an excess of urea and urates, and often a deficiency of chlorides. Albumen is frequently met with in all forms of fever.

The **blood** in inflammatory fever doubtless undergoes important changes, but their exact nature is still imperfectly understood. In the days when venesection was a regular part of the treatment of every febrile condition, much attention was paid to the blood that was drawn. It was noticed that in many acute inflammatory affections the blood coagulates slowly, and—partly from this cause and partly from the rapid running together of the corpuscles into dense masses, which sink quickly—an upper colourless layer of coagulated fibrin free from red corpuscles is left at the top of the clot when it is allowed to form quietly in a deep vessel. The tough layer of yellowish fibrin thus formed received the name of the "*buffy coat.*" The absence of corpuscles allows the contraction in the colourless part of the clot to be much more complete than elsewhere, and its upper surface consequently is depressed in the centre, being "*cupped,*" as it is termed. The "buff and cup" were formerly much used as guides in estimating the intensity of the inflammation; it has, however, been shown that the buff may occur in other conditions of the system, as in plethora, or pregnancy, or after exercise, without the occurrence of inflammation. The cupped shape of the clot is in some degree dependent on the shape of the vessel into which the blood is received, being most marked when it is deep.

The changes that occur in the plasma are due chiefly to the admixture therewith of the products of inflammation taken up from the affected part by the lymphatics and blood-vessels; and it is evident therefore that they must vary considerably according to the nature and intensity of the local process. If the inflammation affects some important organ, the function of which is to

take part in the preparation of the blood, or to eliminate from it the products of tissue-change, its composition must be materially altered; but it is at present impossible to state with any definiteness the exact nature of the changes that take place. In simple inflammations, the fluid draining away from the inflamed area contains, as before stated, an excess of the so-called fibrin-ferment, and it is possibly due to this that the amount of coagulated fibrin which can be obtained from a given quantity of blood is increased in some inflammatory affections. In inflammations accompanied by putrefaction of the discharges, the products of decomposition are added to the fluids entering the circulation by means of the lymph-stream, and with these, microscopic organisms often find their way into the blood. The bacteria which accompany ordinary putrefaction soon perish in healthy blood, being apparently incapable of finding nutriment amongst living tissues. In true infective inflammations, the inflammatory products which enter the blood-stream may in some cases bear with them organisms capable of multiplying amongst the living tissue and giving rise to secondary local mischief or fatal general disease.

The *corpuscles* of the blood, both white and red, may show considerable deviation from the normal standard in number during inflammation. There is no reason to believe that in simple inflammations there is any material change in the number of red corpuscles; but in infective inflammations with high fever and in those accompanied by the absorption of the products of putrefaction, there is undoubtedly a rapid destruction of the red corpuscles. In those cases they often show a tendency to aggregation in irregular clusters instead of the well-formed rouleaux seen in normal blood. The number of white corpuscles in the blood during inflammation has been said by Virchow, Gulliver, and others, to be increased. T. P. Gostling has made a series of observations on this point in the wards of University College Hospital. The corpuscles were counted by means of Gowers's hæmocytometer. The conclusions arrived at were briefly as follow: The white corpuscles are increased in the blood in all inflammations reaching the stage of suppuration, especially if the pus is pent up in a cavity; they are also slightly increased in parenchymatous inflammations such as acute pneumonia. They are not increased in inflammations accompanied only by "serous or sero-fibrinous exudations." According to Virchow, the increase in the white corpuscles is due to stimulation of the lymphatic glands, through which the excessive lymph-stream passes from the area of inflammation.

Varieties of Acute Surgical Fever.—Acute inflammatory fever presents an infinite variety of form; the type which it assumes being dependent, first on the nature of the pyrogenic substance the admixture of which with the blood is the cause of the disturbance; secondly, on the previous health and strength of the patient; and thirdly, on the occurrence of certain local symptoms determined by the seat of the inflammation. These varieties in the type of the fever arrange themselves practically into two classes—1, sthenic, and 2, asthenic. The terms "sthenic" and "asthenic" are not used at the present day with reference to varieties of inflammation as they were in former times; but for the designation of the different forms of febrile disturbance, as observed clinically, we have no better names, and it is convenient to continue to employ them.

1. *Sthenic Inflammatory Fever* occurs in young or middle-aged individuals

of healthy constitution. It is the form usually assumed by the fever that results from the absorption of a moderate quantity of the chemical products of putrefaction from a large wound during the first week after its infliction, and it is also often seen in acute inflammations of important organs, or during the formation of acute abscesses.

The stage of invasion is slightly marked: there is chilliness or shivering with a feeling of general illness; but these symptoms may be so transient as to escape observation. In the majority of cases it is not until the constitutional disturbance is fully developed that it attracts attention. The skin is hot, and there is a rise in the temperature of the body of from 2° to 5° Fahr. The evening temperature is one or two degrees higher than that observed in the morning. There is a feeling of general languor, and the head is often heavy and hot. The pulse is full, bounding or thrilling, and quickened to thirty or forty beats in the minute above its normal rate. The character of the pulse varies with the part affected and with the cause of the fever. In ordinary traumatic fever, when it assumes the sthenic form, in the formation of acute abscesses, and in the early stages of many specific inflammatory fevers, as erysipelas, the pulse is full and bounding; in inflammation of glandular structures, as the testis or mamma, it is compressible though full; in acute inflammation of serous membranes, as in pleurisy, peritonitis, or meningitis, it is small, compressible and wiry. The secretions are arrested or diminished in quantity, the tongue is coated with a white fur, and the mouth clammy, usually with much thirst; the bowels are confined, and the skin dry. The urine is scanty and high-coloured.

In surgical cases the fever commonly terminates gradually, by *lysis*, but it may cease suddenly by *crisis* if the local cause can be removed. The tongue becomes clean, the pulse lessens in frequency and in strength, the secretions become more free, the thirst diminishes, and strength and appetite return. This favourable termination can occur in most surgical cases only by the removal of the cause of the fever, as by the opening of an acute abscess, the removal of septic matter by drainage, or the growth of healthy granulations preventing its further absorption. Should the cause persist, the fever may terminate in death, either by exhaustion or by the supervention of some visceral complication, as pneumonia; or the sthenic form may gradually merge into the type that is characterised by debility.

2. *Asthenic Inflammatory Fever* occurs in those individuals whose constitutions are broken down by privation, dissipation, or by any of the general depressing causes of disease, as grief, anxiety, long residence in a vitiated atmosphere, or old age. In constitutions such as these, frequently met with in all classes, but especially amongst the poorer residents in large towns, inflammatory fever almost invariably assumes this type. The cause of the fever, however, in many cases, determines the type quite as much as the constitutional state of the patient. When it is due to a large dose of the products of putrefaction rapidly absorbed it is asthenic from the first, or rapidly becomes so. The same form is met with in almost all true cases of infective blood-poisoning from wounds; that is to say, in those cases in which the poison which enters the system is not merely the chemical products of putrefaction, but a ferment-like substance capable of multiplying in the living body, as in acute septic infection, pyæmia and malignant pustule. In all spreading gangrenous inflammations the fever assumes the same form; and in ery-

sipelas, although, as before stated, there may be sthenic fever for a short time, the signs of exhaustion rapidly set in. As the asthenic form of fever depends so frequently on general infective processes it is often accompanied by secondary complications, as pleurisy, pneumonia, visceral abscesses and the like.

When the asthenic form comes on as a sequel of the sthenic, the symptoms of the one gradually merge into those of the other, the weakness increases, the pulse becomes feebler though its frequency is kept up, the tongue becomes brown and dry, and there is tendency to delirium of a muttering kind.

When the fever assumes the asthenic form from the very first, depression is often strongly marked during the period of invasion; and, even when the febrile state is fully established, the symptoms are not very active. There is throughout an appearance of heaviness and stupor about the patient, and an early tendency to delirium of a low and muttering form, especially at night; the pulse is feeble and very frequent; the skin may be hot and dry, or sometimes moist and clammy; the temperature is from 2° to 5° Fahr. above normal, and shows a marked evening rise and morning fall; the tongue is brown and dry, and sordes rapidly accumulate about the lips and teeth; the cheeks are often flushed, and the eyes may be bright and staring. If the patient recover, there may be a critical evacuation, as sweating or diarrhœa; the pulse subsides in frequency and increases in strength, the tongue gradually and slowly cleans from the sides and tip, the temperature falls often below normal for some days, and the patient slowly and imperfectly regains his strength. Owing to the extreme feebleness of the heart's action that often accompanies this form of fever there is a great tendency to local congestions, especially hypostatic pneumonia, which may interrupt progress towards recovery.

If the disease take an unfavourable course, the weakness of the pulse and the dark incrustation of the tongue increase; the temperature often falls below normal; the skin becomes cold and clammy; hiccough, subsultus and dyspnœa supervene; the muttering delirium gives way to insensibility or even to coma, and death occurs from exhaustion, or as the result of visceral complication. It is this condition that is frequently described as the "setting in of typhoid symptoms."

In patients whose nervous systems have been shattered by intemperance, or who have been exhausted by excessive mental work or excitement, the nervous symptoms that accompany the febrile disturbance may form so prominent a feature of the case as almost to justify the description of a third type, as has been sometimes done, under the name of **Irritative Fever.** In these cases, if the fever assume the sthenic form there is high delirium, often of a furious kind, with wildness of the eye, flushed face and heat of head. More often the fever is from the first of the asthenic type, especially in habitual drunkards, in whom it resembles delirium tremens; there is the same tremor, clammy perspiration and foul tongue, and the delirium is not violent but busy and muttering, the patient being restless and constantly trying to get out of bed; he is sleepless, and unless relief be obtained, signs of debility rapidly show themselves, and death takes place either from exhaustion or coma.

TREATMENT OF ACUTE INFLAMMATION.

The knowledge we obtain of the causes and nature of inflammation in the dead-house and in the pathological laboratory serves to some extent to guide us

in its treatment. Still our knowledge is not yet sufficiently perfect for theory alone to direct our practice, and we must on no account neglect those modes of treatment which have been shown by experience to be of use.

Before describing in detail the means adopted in surgical practice for the prevention and cure of inflammation, it will be well briefly to point out the indications furnished us by pathology.

1. Inflammation is the result of an injury done to the living tissues, of sufficient severity to lower the vitality of the affected part, but not actually to kill it. Our first object, therefore, in the prevention of inflammation, is *to protect the tissues from all sources of irritation and, failing this, to remove the original irritant as quickly as possible, and to prevent the introduction of fresh causes of irritation.*

Under this head are included :—the removal of foreign bodies; the avoidance of irritating applications; the prevention of tension, by drainage of wounds and suitable position of injured parts; the relief of tension, as by early opening of abscesses, or by incisions to allow of the escape of inflammatory exudation; and the prevention of decomposition in the discharges of wounds and abscesses, and the exclusion of specific infective poisons, such as that of erysipelas, or the like.

2. All irritants lower the vitality of the tissues upon which they act, and if of sufficient intensity, cause death of the part. The degree of damage done is proportional, first, to the intensity of the irritation, and, secondly, to the vitality, or, in other words, to the power of resistance of the tissues. In the prevention of inflammation, or in the limitation of the process, our first object must be to do everything in our power, both by general and local means, *to promote the healthy nutrition of the tissues.*

Under this head come :—attention to diet; avoidance of alcoholic excess; regulation of the action of the bowels, skin and kidneys; the treatment of constitutional conditions, such as gout, rheumatism, and syphilis. Locally the chief objects to be kept in view are—to preserve a normal state of the circulation by removing causes of congestion, or local anæmia, as by the excision of tumours pressing on vessels, the cure of varicose veins, and the relief of the distended capillaries by uniform elastic pressure; by elevation of the part, or the removal of strangulation; to maintain a normal temperature; and to avoid over-work of the part, as excessive use of the eye or larynx.

When the inflammatory process is established, the vitality of the part is lowered, and our main objects are—to avoid further depression, which might extinguish such life as remains; to encourage the return of vitality by the maintenance of a normal temperature and by the regulation of the disturbed circulation by such means as we have at our command; and to ensure as far as possible both functional and mechanical rest of the inflamed part.

Inflamed parts are less able to withstand the effects of heat and cold, of chemical irritants, or mechanical violence. Thus, the application of cold or of powerful antiseptic solutions (all of which are more or less irritating), or the necessary injury of a surgical operation, may, in an inflamed part, intensify the process, and even cause sloughing.

3. The essential phenomena of inflammation are: first, the dilatation of the arteries with increased blood-pressure in the area supplied by the dilated vessels; secondly, the exudation through their damaged walls, which, other things being equal, will be proportional to the degree of intravascular

pressure; thirdly, the migration of the white corpuscles; fourthly, the complete arrest of the circulation by stasis. The vascular dilatation and exudation cause the inflammatory swelling and give rise to tension, which, acting as a fresh source of irritation, aggravates the inflammatory process. One of the primary objects in the treatment of inflammation is *therefore to limit the exudation by diminishing the blood-pressure and, failing in that, to relieve the tension it gives rise to.* The blood-pressure may be limited, first, by general means acting upon the heart, as aconite, antimony, and general blood-letting; and, secondly, by diminishing the quantity of fluid circulating in the body, as by general blood-letting, saline purgatives, or low diet. The local blood-pressure may be diminished by causing dilatation of the vessels of some other parts—as of the intestines by purgatives in external inflammations, or of the skin by diaphoretics in internal affections; secondly, by causing contraction of the vessels supplying the inflamed area by the direct application of cold, belladonna, or astringents, or by employing a stimulus at a distance, so as to cause a reflex contraction of the vessels of the diseased part, as in counter-irritation by blisters or mustard plasters; thirdly, by causing a uniform dilatation of all the vessels of the inflamed part and its immediate neighbourhood, so as to lessen local resistance, as in the application of heat; and, fourthly, by elevation of the affected part of the body, by which the return of blood from the part is favoured, and, as has been shown by Lister, a certain degree of arterial contraction induced. Direct pressure on the main artery of the limb would also come under this heading. When exudation is taking place, elevation of the limb favours its return by the lymphatics, and so lessens swelling. Should the part become so much distended as to threaten gangrene from pressure on the vessels, the exudation may be allowed to escape directly by incisions, punctures or scarifications. The migration of the corpuscles is limited by cold, which arrests their amœboid movements, and by all means which diminish blood-pressure. Heat favours their migration, and also encourages their moving out of the inflamed area into the lymphatics in cases in which resolution is taking place. It is only the return of vitality in the walls of the vessels, however, that can completely arrest the process of migration.

The tendency to inflammatory congestion, that is to say, choking of the distended vessels with scarcely moving blood, can be relieved in some cases by drawing blood directly from the part by scarification or puncture, or the force of the heart's action may be stimulated by the administration of alcohol in order to drive the blood past the obstruction. Stasis can be relieved only by the general means above mentioned for favouring the return of vitality in the inflamed area.

4. Pain, which forms so prominent a symptom in many inflammations, will be relieved locally by those means, already mentioned, which tend to diminish tension; but in addition, local sedatives—as belladonna, opium, or subacetate of lead—are often of great use. If these fail, sedatives must be given internally.

5. Lastly, the treatment of inflammation includes that of the *febrile disturbance* which accompanies it. This, as we have seen, may be due chiefly if not entirely to the admixture with the blood of the exudation returning from the inflamed part by the lymphatics; in such cases the means adopted to limit the exudation, or to drain it away externally, as in a wound, will limit the fever; in other cases the stream of lymph bears with it the chemical pro-

ducts of decomposing matter from the inflamed area, and thus acquires an additional power of causing fever; this can be prevented only by proper antiseptic precautions, or by draining off the exudation externally. In specific infective inflammations the fever may be due to contamination of the blood by the presence of some poison multiplying in it, as in septicæmia (septic infection), pyæmia, or malignant pustule. At present we are not acquainted with any means of definitively destroying the poison in such cases; we can only support the patient in every way in our power, by food and careful nursing, so as to enable him to withstand its evil influence. In those cases in which the nervous symptoms of fever are predominant, sedatives must be administered internally. Lastly, certain drugs are used empirically, from their known power of reducing the temperature in fever, amongst the most important of these being alcohol, quinine, salicylate of soda, aconite, antipyrin, antifebrin, phenacetin, &c. The application of cold generally to the body by baths or wet packing, or locally to the head by an ice-cap, as recommended by Knowsley Thornton, useful as they undoubtedly are in cases of very high fever, are but empirical modes of treatment, as they attack one symptom only, leaving the cause untouched. *No Surgeon should rely solely on such means as these unless it is beyond his power to discover, or to remove, the cause of the fever by cutting off the supply of the pyrogenic substance,* as by opening an abscess, establishing proper drainage in a wound, or cleaning out septic matter from any cavity in the body.

The above principles serving more or less as our guides, we can now consider more in detail their practical application in the treatment of acute inflammation.

The Preventive Treatment of inflammation can be employed only in cases of injury. All injuries of any severity—as cuts, bruises, sprains, or fractures—must necessarily be followed by a certain degree of inflammation; but this simple traumatic inflammation has no tendency to spread beyond the area injured, which, in the case of a clean-cut wound, is little more than a microscopic layer of tissue; nor does it tend to pass beyond the stage of simple exudation into that of suppuration or ulceration, unless some further cause of irritation come into play after the injury. When we talk, therefore, of the prevention of inflammation, we do not mean the prevention of the simple adhesive inflammation which follows an injury, for that is impossible; but we mean the exclusion of all sources of irritation which could intensify or prolong the process or make it assume a spreading form. The irritants we have chiefly to guard against are the products of putrefaction and the specific poisons of the various infective inflammations. The essential cause of putrefaction being an organised ferment, and the actual virus of almost all infective inflammations being of the same nature, the exclusion of micro-organisms from the injured area forms the most essential part of the preventive treatment of inflammation. The simple non-pathogenic, or septic organisms, cannot live in the blood-stream, and consequently always find their way to the injured part directly from without, being carried to it either by the air, or in water, or on solid bodies, such as the instrument inflicting the wound, or the Surgeon's hands, or from the patient's own skin. On the other hand, there is strong reason to believe that some pathogenic organisms may enter by the lungs or alimentary canal and be carried by the blood-stream to the injured part, although, doubtless, they far more commonly enter an open

wound directly from without in the same way as the non-pathogenic organisms. Local means calculated to exclude or destroy micro-organisms will prevent putrefaction almost with certainty. The same means will also prevent the great majority of infective inflammations. The association of putrefaction with the specific infective inflammations is so close that the two subjects cannot be dealt with separately in so far as local treatment is concerned, and here, therefore, we need deal only with the prevention of putrefaction.

The **prevention of putrefaction** may be carried out by the exclusion of any one of the essential conditions for the process (p. 177). The first of these is the presence of dead organic matter. It is our object, therefore, by drainage of wounds and abscesses, either entirely to remove the putrescible matter or to reduce it to so small a quantity that the effects of its putrefaction will be insignificant. The next three conditions, the presence of oxygen, water, and a certain degree of temperature, cannot be excluded from any abscess, wound, or cavity of the body; but the discharges flowing from these may be either received in some absorbent material or allowed to dry in the air, and thus their decomposition may be prevented; and it will be seen, in the treatment of wounds, that these methods are often adopted. The last condition of putrefaction is the presence of the organised ferment; and the destruction or exclusion of this forms the essential feature of those modes of treating wounds, abscesses, or ulcers, which aim at the prevention of the inflammation which results from the irritation of the chemical products of putrefaction. The simplest mode of exclusion of the organisms floating in the air is by *filtration*. It has been shown by experiment that the air filtered through pure cotton-wool is incapable of giving rise to putrefaction or other fermentative changes; but this mode of preventing decomposition and infection, although often forming an accessory to other means, can scarcely ever be employed alone in surgery. Septic organisms are much more commonly carried by water or by solid bodies, as the Surgeon's hands or instruments, and consequently our chief reliance has to be placed on *chemical antiseptics*—that is to say, on chemical substances capable of destroying the vitality of minute vegetable fungi. It must not be forgotten, however, that all chemical antiseptics are in themselves irritants; and in using them care must be taken to protect the tissues as far as possible from their direct action, otherwise they may act as causes of inflammation although preventing putrefaction. As we shall have frequently to refer to the use of antiseptics in the treatment of abscesses, ulcers, and wounds, it will be most convenient here to mention the chief substances at present employed, with their properties and peculiarities. Antiseptics vary much in their power, in the irritation they give rise to, and in their effects if absorbed; these points will therefore be alluded to.

It may be stated that no antiseptic vapour, of which any practical use can be made in surgery, has yet been discovered.

Carbolic Acid is, perhaps, still the most extensively used of all antiseptics, though by no means the most powerful. In surgery the purest acid only should be used, the form known as absolute phenol being the best. The impure acid, such as is used for disinfecting drains, is more difficult of solution in water, and its smell is very offensive. The pure crystallised acid may be made permanently to assume the form of a dense oily liquid by the addition of about $\frac{1}{10}$th of its bulk of water, but true solution does not take place till the proportion of water is about 19 to 1 of the acid, thus forming the 1 in 20

solution. The efficient strength of the watery solution as an antiseptic is about 1 in 50, below which it must not be reduced. Carbolic acid is readily soluble in oil or glycerine in any proportion up to equal parts. The preparations used in surgery are :—*Watery solutions*, 1 in 20 and 1 in 40. The former is applied to foul wounds for the purpose of cleaning them, to wounds which have been exposed to the air for some time, and to the unbroken skin round the region in which an operation is to be performed; the latter is used to wash the operator's hands and the sponges, and all instruments used during the operation, and to irrigate the wound during the performance or to wash it out at the end before closing it. The 1 in 20 solution is used for the spray, as will hereafter be described. Both the 1 in 20 and the 1 in 40 solution whiten any raw surface to which they may be applied, but their action is very superficial, and does not interfere with primary union of a wound. At the moment of application they cause severe smarting, but this is soon followed by a sensation of numbness. *Oily solutions* act much less powerfully than the watery. For preserving catgut ligatures a solution of 1 in 5 must be used. In the strength of 1 in 10 it may be applied on lint to a wound as an antiseptic dressing, but it loses its acid rather quickly, especially if there is much discharge, and consequently must be renewed at least twice or three times a day. *Glycerine solutions.* The pharmacopœial solution of 1 in 5—one part of carbolic acid to four of glycerine—is too strong for application to a raw surface, but may be used on the unbroken skin; for wounds the solution may be reduced to 1 in 10 by the addition of an equal quantity of water or glycerine. If used as an antiseptic dressing it must be changed frequently, as it is readily washed out of lint by the discharge. *Carbolic gauze.* This is a coarse gauze impregnated with carbolic acid dissolved in a mixture of paraffin and resin. It contains about $\frac{1}{12}$th part of carbolic acid. It forms an absorbent dressing, and possesses the great advantage of yielding up its carbolic acid slowly, and thus retaining its antiseptic properties for a long time. *Carbolised cotton-wool and tow* have also been used, but are somewhat inefficient preparations.

Carbolic acid may act injuriously both locally and generally. If the solution be not properly prepared, small globules of the undissolved acid may be floating in it which will cauterise both the patient's tissues and the Surgeon's hands. To avoid this it is better always carefully to measure the acid and to prepare the solutions some hours before they are used. If the solution is prepared immediately before use it must be well stirred; and, if it is not required to be cold, warm water may be used to ensure perfect solution.

Carbolic acid is, even in the strength of 1 to 40, an irritant to the living tissues; when applied to a wound it exaggerates the serous discharge for the first twenty-four hours, and consequently increases the necessity for good drainage. In using it as a dressing the object of the Surgeon must be to prevent direct contact of the acid with the raw surface as far as possible after the wound has been once washed out; otherwise it may give rise to suppuration. In washing out a wound also it is important to take care that the lotion used escapes freely. If it remains in hollows and cavities of the wound its absorption may cause poisoning; and if it be forced into the spaces of the areolar tissue, considerable local inflammation may supervene. In some patients the skin is singularly intolerant of the acid, and the gauze may cause even vesication. Its use must then be abandoned, and some other anti- agent employed in its place.

Carbolic acid cannot be applied either to the unbroken skin or to a raw surface without a certain quantity being absorbed. As a rule this gives rise to no unpleasant symptoms; but, if the surface be very large or the patient be peculiarly intolerant of the acid, symptoms of carbolic poisoning may arise. In every case in which a carbolic acid dressing of any kind is applied, it or its derivatives can be detected in the urine by proper tests; and if a surface of any size is covered by the dressing or a large wound is washed out with the lotion, the urine frequently undergoes a marked change. In the mildest cases it is passed clear, but after standing for some time gradually assumes an olive-green tint; in the more severe cases it is passed dark in colour, and on standing becomes almost black. If no other symptoms are present this need give rise to no anxiety. In cases in which the graver symptoms of poisoning are present, the sulphates disappear completely from the urine. The most marked feature of carbolic acid poisoning by absorption from a wound is severe and uncontrollable vomiting; if the dose has been very large, collapse speedily sets in, with insensibility of the pupil, twitching of the muscles, a rapid feeble pulse, and a subnormal temperature. Albumen is said to appear in the urine. In other cases elevation of temperature has been noted, with vomiting followed by insensibility and death. With the exception of a few recorded cases, which must be attributed to an idiosyncrasy on the part of the patient, dangerous symptoms have occurred only when the carbolic lotion has found its way into some cavity as the rectum, peritoneum or pleura, or when large abscess-cavities have been washed out with the lotion, or when it has been forced into the spaces of the areolar tissue in attempts to disinfect deep wounds or compound fractures. The treatment consists in immediately removing all carbolic acid dressings and substituting some other antiseptic. The patient must be supported by stimulants, especially hypodermic injections of ether; and friction of the surface should be employed. Ice may be given to allay the vomiting. Baumann has recommended the administration of sulphate of soda in small doses frequently repeated, with the hope of converting the carbolic acid into the non-poisonous sulpho-carbolate. This treatment was suggested by the disappearance of the sulphates from the urine, which is possibly due to their having been consumed in that way; the graver symptoms supervening when they are exhausted and free carbolic acid becomes present in the blood. The drug can do no harm and should always be tried.

Carbolic acid has now been more than twenty-five years before the profession as an antiseptic, and has derived great importance from being the agent first selected by Lister for his antiseptic system of treating wounds. In spite of the efforts of Lister himself and other Surgeons to find some substitute which shall be free from the inconveniences attending the use of carbolic acid, it still holds its place as one of the most generally useful and efficient of all antiseptics. It has no injurious effect on steel, and consequently it is used for disinfecting surgical instruments even by those Surgeons who employ some other substance for cleaning their hands and washing out or irrigating wounds.

Salicylic Acid is a derivative of carbolic acid, possessing no toxic properties. It requires at least 300 parts of cold water to dissolve it, and is in this form a less certain antiseptic, though less irritating, than carbolic acid. The preparations used in surgery are *salicylic wool*, *salicylic jute*, and *salicylic silk*. The jute is recommended by Thiersch as being more absorbent; the

silk is prepared from refuse material, and was introduced by McGill of Leeds: it is very absorbent and elastic. All these preparations contain a proportion of the acid varying from 3 to 10 per cent. They should be moistened with a little glycerine to prevent the dust of the acid from flying about when they are used, as it causes violent sneezing. Salicylic acid in solution corrodes instruments.

Perchloride of Mercury.—Attention was first directed to corrosive sublimate as an antiseptic by Koch, who showed that in the extreme dilution of 1 in 20,000 it was capable of killing, in ten minutes, the spores of the *bacillus anthracis*, one of the most resisting of all known organisms. The results of these experiments cannot, however, be applied without modification to the prevention of decomposition in albuminous fluids, for corrosive sublimate forms with albumen a compound known as "mercuric albuminate," which, although not inert, possesses far less active antiseptic properties than the watery solution. Thus, Mikulicz found that the addition of one part of corrosive sublimate to 2,000 parts of a mixture of equal parts of blood and water entirely failed to retard putrefaction and the development of bacteria; when added in the proportion of 1 in 1,000 these processes were retarded, but not prevented, and it was not till the proportion of 1 in 400 was reached that the development of bacteria was completely excluded. From these observations it is evident that the addition of perchloride of mercury to water in the proportion of 1 to 5,000 will certainly destroy every living organism in it. Such a solution may therefore be used to wash fresh wounds without any fear of infecting them either with septic or pathogenic organisms. A watery solution of this strength would, however, be quite inefficient as an antiseptic should it become mixed with any albuminous fluid, and consequently it is safer to use a solution of 1 in 2,000, or 1 in 1,000, for irrigating wounds during an operation, and the same strength is employed for cleaning the Surgeon's hands and for washing sponges. A solution of 1 in 500 may with safety be used to clean a foul abscess, but it must be applied with a sponge and the cavity afterwards dried with another sponge squeezed as dry as possible. For cleaning unbroken skin 1 in 500 may be used with impunity, but it must be remembered that, unlike carbolic acid, it will not act efficiently on a greasy skin. The grease must be removed by abundant washing with soap and hot water followed by a weak solution of ammonia. Solutions of corrosive sublimate prepared with ordinary water, deposit, after some time, an insoluble precipitate containing a considerable proportion of the mercury, amounting to more than 50 per cent. of that present if the water be very hard. If the solution is to be kept for any time, it is therefore usually recommended to prepare it with distilled water. Angerer of Munich has, however, shown that the precipitation may be prevented by the addition of an equal quantity of common salt to the perchloride. He recommends that the salt and sublimate should be fused together into small cakes containing enough to make a definite quantity, as a quart or more of the 1 in 1,000 solution. In this form the antiseptic can be readily carried in military surgery.

In preparing dressings to absorb the discharges of wounds or abscesses a larger proportion of sublimate must be added, for the reasons above given; the proportion most commonly adopted being about $\frac{1}{2}$ per cent. of the weight of the material used. For instance, to prepare gauze or wool, a solution is

made containing 1 part of perchloride of mercury, 450 of water, and 50 of glycerine. The wool or gauze is soaked in this for a few minutes, and then squeezed as dry as possible in a wringing-machine. It is next hung up to dry as far as the glycerine will permit, and is then ready for use. Jute, sphagnum moss, peat, sawdust, ashes, sand, and a variety of other absorbent substances may be prepared by being soaked in a 1 in 500 solution and dried. Small pads or cushions may be prepared by filling bags made of the gauze with any of the above materials. When applied as dressings, they are secured by bandages prepared in the same way. Bruns introduced a material made by grinding pine-wood, and known as "wood-wool," which from its softness, elasticity, and power of absorption makes an excellent dressing when prepared as above described.

Corrosive sublimate has proved a most efficient, useful, and economical antiseptic, but like all others it has its drawbacks. Amongst its advantages, especially in military practice, must be included the concentrated form in which it can be carried, and the ease with which almost any absorbent substance can be impregnated with it without the employment of any special apparatus. Like all other powerful antiseptics, however, it is irritating and poisonous, and as it possesses these properties in a higher degree than most others, a corresponding degree of caution is necessary in the preparation of the solutions and dressings and in their use. The maximum medicinal dose of the perchloride is contained in about 4½ drachms of the 1 in 1000 solution, and it is evident, therefore, that in using such a preparation in a large hollow wound, a serous cavity, or a mucous canal, care must be taken that a poisonous dose be not left behind. Should such an accident happen, or should the patient be peculiarly susceptible to mercury, he is seized with pains in the belly, and diarrhœa with tenesmus and bloody motions. This may be followed by collapse and death, or the fatal result may be occasioned by exhaustion from constant diarrhœa. The colon and rectum, and sometimes the small intestine, in such cases are found to be acutely inflamed and superficially ulcerated. *Salivation has rarely been observed.* The number of cases on record in which fatal poisoning has followed the use of perchloride of mercury as an antiseptic is very considerable if those occurring in obstetric practice are included. In any case in which there is evident danger of such an accident, the strength of the solution should on no account exceed 1 in 2000.

Local irritation from sublimate dressings rarely occurs if the proportion of mercury is not too great. When it does happen, there may be redness and vesication or a superficial inflammation resembling eczema.

Sal Alembroth, a double chloride of mercury and ammonium, has been suggested by Lister as a substitute for the pure perchloride in preparing dressings. Its advantages are, that it is less irritating, and less prone to form an inert compound with albumen. Gauze impregnated with 1 per cent., and wool with 2 per cent., are the preparations that have been used. The only disadvantage which sal alembroth presents is its extreme solubility. It is very readily washed out of the dressing by an abundant discharge. The gauze and wool as sold are stained with an aniline blue to distinguish them.

Cyanide of Mercury and Zinc.—A combination of these cyanides of somewhat uncertain composition has been introduced as an antiseptic by Lister, and is now extensively used. It is insoluble in water, but

soluble in blood-serum in the proportion of 1 in 3000. It has little or no tendency to combine with albumen. The salt dissolved in serum has but feeble powers as a germicide if tested by its action on the spores of bacilli, but, on the other hand, its powers of inhibiting their growth are very considerable, and this is, from a practical point of view, all that is required for an antiseptic dressing. The preparation used is a gauze impregnated with the cyanides. It is a beautifully absorbent and a very efficient dressing. It is coloured mauve with rosolane, an aniline dye, which serves to fix the double salt in the gauze.

Creolin is a preparation of gas-tar closely resembling the original material in appearance and smell. It is said to be non-poisonous and free from carbolic acid. It is insoluble in water, but in the strength of 1 to 3 per cent. it forms an emulsion which can be used as a lotion to wash a wound or to moisten a dressing. The emulsion must be freshly prepared for each dressing, as it soon changes into a dirty brownish liquid on standing. It can also be used in the form of ointment. There is no doubt that an emulsion of creolin, from the strength 1 per cent. upwards, is a most efficient and unirritating antiseptic.

Chloride of Zinc.—The efficient strength of this antiseptic, which is the active principle of Burnett's fluid, is doubtful. According to Koch, a solution of about five grains to the ounce will not certainly kill non-spore-bearing organisms, and one of twenty grains to the ounce has no effect whatever on the spores of the *bacillus anthracis*. Its use in the treatment of wounds was introduced by Campbell De Morgan more than thirty years ago. It is usually employed in the strength of forty grains to the ounce of water. This solution produces a whitening of the surface, but the action is very superficial, and it does not cause the formation of a visible slough unless applied for some length of time; in fact, even in this strength, it does not prevent union by first intention. The whitened surface has been shown by experiment to form a remarkably efficient barrier to the absorption of the chemical products of putrefaction, and experience proves that decomposition of the discharges will not commence for about three days in a wound thus treated. It therefore forms a most useful application to wounds in which it is impossible to employ strict antiseptic treatment, such as those opening into the mouth, rectum, or bladder; for by the third day, when its influence seems to be exhausted, the opened lymph-spaces are so far closed by plastic exudation that the dangers of septic absorption are greatly diminished. It has no toxic effects when thus applied, but it must never be injected in this strength into any cavity or wound, as should any quantity be left behind, or should the lymph-spaces be injected, it may cause serious and extensive sloughing. It must be used only where the surface can be dried afterwards with a sponge.

Boric Acid was introduced into surgical practice by Lister. It is one of the less powerful, and at the same time one of the least irritating, of chemical antiseptics. It is soluble in 26 parts of cold water or in 3 of boiling water. Its efficient strength as an antiseptic is said to be about 1 in 130 or four grains to the ounce, but the concentrated cold solution or "*boric acid lotion*" is more commonly used. It is prepared by adding one ounce of the crystallised acid to a pint of boiling water, and afterwards allowing it to cool and the excess of the crystals to settle down; it forms a useful lotion for washing or irrigating wounds. Glycerine may be added to the lotion in the proportion of half a drachm to one ounce to prevent its drying when used, as to moisten a dressing.

Boric acid lint, which is prepared by dipping ordinary lint in a concentrated boiling solution of the acid and afterwards drying it, forms a useful application to wounds or granulating sores; and, if moistened with warm boric acid lotion, it may be applied with great advantage in the place of a poultice to sloughy and inflamed wounds. *Boric acid ointment* forms an excellent dressing for small wounds, such as those on the face, and for healthy granulating sores. It is now officinal. It should be spread on thin muslin and dipped in the boric acid lotion before being applied, after which it may be covered with cotton-wool and allowed to dry. It requires changing once or twice a day.

Sulphurous Acid is but little used as an antiseptic on account of its extremely unpleasant smell and its irritating properties.

Eucalyptus Oil is a powerful antiseptic, having a very fragrant camphoraceous smell; it is quite free from poisonous properties. It is practically insoluble in water, but readily dissolves in oil, paraffin, and spirit. It has been used in the form of eucalyptus gauze as a substitute for carbolic gauze in cases in which the patient showed signs of carbolic poisoning, or when the skin was irritated by the dressing, but, owing to the volatility of the oil, it soon deteriorates at the temperature of the body, and becomes useless after about twenty-four hours. For application to granulating sores an ointment composed of 2 parts paraffin, 2 vaseline, and 1 of eucalyptus oil will be found very useful. If the sore be foul some iodoform may be added in the proportion of one drachm to the ounce.

Iodine is one of the most powerful of all antiseptics. It has been recommended by Bryant as a lotion for washing wounds and sponges, in the strength of two drachms of the tincture to a pint of warm water; and in this strength it is an efficient antiseptic and very free from irritating properties.

Iodoform is an antiseptic of undoubted power which is used very largely in surgical practice. It is an iodine compound of methyl alcohol. It is sold in two forms—the precipitated, which is an extremely fine yellow powder; and the crystalline, composed of fine golden yellow crystals. The latter should always be used in wounds or on raw surfaces, as the finely divided particles of the precipitated form are too readily absorbed. Iodoform is insoluble in water but is readily soluble in chloroform and ether, sparingly so in alcohol, and very freely in oil. The preparations used in Surgery are the pure drug in crystals; *iodoform wool*, prepared by impregnating cotton-wool, deprived of its grease so as to render it absorbent, with 10 per cent. of the drug; *iodoform gauze* containing 20 per cent. of the drug; and *iodoform ointment*, made by mixing varying proportions of the crystals from one drachm upwards with one ounce of vaseline. The pure iodoform is specially applicable to wounds opening into cavities, such as those left by removal of the tongue or upper jaw. It may be sprinkled on the raw surface twice a day, and will completely prevent any unpleasant smell. The Germans have used it freely as an application directly to the raw surfaces of fresh wounds before closing them, and it has been found not to prevent union by first intention, but its use in this way is not to be recommended, as it is a needless introduction of a foreign body.

According to the ordinary modes of testing antiseptics by their power of destroying micro-organisms and their spores in laboratory experiments, iodoform is practically useless, but no Surgeon who has experience of its efficacy in operations on the mouth or rectum will doubt that it is one of our most

valuable means of preventing putrefaction and infection. This discrepancy is said to be explained by the fact that iodoform breaks up in the presence of pus, so that pure iodine is liberated. Ptomaines are also said to break up iodoform in the same way and at the same time to be themselves destroyed. Free iodine is well known to be one of the most powerful of all antiseptics, and thus the power of iodoform in checking decomposition and suppuration is fully explained. If much iodoform is used, iodine can always be detected in the urine in the form of iodides; but iodoform does not appear; this is further evidence of its breaking up, either in the wound or the blood.

Iodoform possesses very marked toxic properties, but the effect produced seems to depend to a great extent upon an idiosyncrasy on the part of the patient. The symptoms of iodoform poisoning are very various, and differ somewhat in children and adults. Amongst the most marked effects have been an elevation of temperature reaching 104° F., without other serious constitutional disturbance, and without any unhealthy appearances in the wound. Loss of appetite with progressive emaciation is common; the patient complaining that everything tastes and smells of iodoform. Vomiting, however, is not a frequent symptom. The effect on the pulse is often very marked, especially in children; the frequency is greatly increased, reaching 140 or even 180, and at the same time the force is correspondingly diminished. Its effects on the brain are often very serious; in some cases in adults it seems to have caused violent maniacal delirium, in others persistent drowsiness has been noted, with great mental depression. In children drowsiness is more common, and occasionally the symptoms may closely resemble those of tubercular meningitis. In other cases rapid collapse has followed the use of iodoform, for which no cause but the drug could be found. Many fatal cases have occurred in Germany; but the quantities applied have been in some cases so enormous that this is scarcely to be wondered at. As an external dressing to a wound, the edges of which have been brought accurately in contact, it has never been known to cause poisoning, though when applied on the raw surface left by a large burn it may give rise to some of the above-mentioned symptoms. The urine, in all cases of iodoform poisoning, has been found to contain iodine. The treatment consists in the immediate and complete removal of the drug, which will usually be followed by speedy disappearance of the symptoms. Iodoform very rarely causes any local irritation. It is said to have little or no power of destroying the virus of erysipelas.

Potassium permanganate, a solution of which is known as Condy's fluid, is a powerful oxidising agent. It possesses very active powers as a disinfectant, destroying the smell of decomposing matter even when used in very dilute solutions. According to Miquel, it prevents the growth of organisms when in the proportion of about two grains to the ounce of water. In the strength of about twenty grains to the ounce it will kill the spores of the *bacillus anthracis*, but such a solution cannot be used in surgery, as it stains everything with which it comes in contact a deep brown colour. The weaker solution forms a valuable lotion or wash for foul wounds. It possesses practically no toxic properties.

Aluminium acetate, in the strength of about ten grains to the ounce, has been recommended as a non-poisonous antiseptic by Maas, and has been extensively used in Germany.

Both the **acetate** and the **subacetate of lead** possess antiseptic properties,

and to this they partly owe the reputation for preventing inflammation in wounds.

Benzoic acid possesses extremely powerful antiseptic properties, but has not been used pure in the treatment of wounds. It forms an important constituent of Compound Tincture of Benzoin, Friar's Balsam, or Wound Balsam, which was formerly extensively employed as an external application to wounds, and is still sometimes applied to compound fractures.

Turpentine was, in former times, a constituent of almost all salves for wounds, and doubtless did excellent service as an antiseptic. At the present time it is scarcely ever used. A highly refined form is sold under the name of *terebene*, which, dissolved in olive oil in the proportion of 1 to 5, forms a useful antiseptic application.

Thymol is the aromatic principle of thyme. It is said to be an efficient antiseptic if dissolved in water in the proportion of 1 in 1000. It is but little irritating and is not poisonous; but it presents few other advantages, and is rarely used except for washing out a cavity, as the rectum, from which carbolic acid might be absorbed in dangerous quantities if injected.

Glycerine possesses feeble antiseptic properties, the efficient strength with water being, according to Miquel, 1 in 4. It is chiefly useful as an addition to boric or carbolic lotions, to prevent their drying too quickly.

Alcohol.—According to Miquel, the efficient antiseptic strength of an alcoholic lotion is 1 in 10, that is to say, two ounces of absolute alcohol or four of proof spirit in a pint. Absolute alcohol has no influence whatever on the spores of pathogenic bacilli. Alcohol is but little used in surgery as an antiseptic, as it evaporates too rapidly, but it may be employed as a wash for wounds or for the hands and instruments if none more efficient is at hand.

OTHER METHODS OF PREVENTIVE TREATMENT.—Amongst the most useful means of preventing inflammation is the application of **cold.** This causes contraction of the vessels, and thus limits exudation and prevents swelling and tension. The cold should not be so intense as to lower the vitality of the injured part, or it may cause the very mischief it is intended to prevent. For this reason it is of doubtful utility in all superficial injuries or in cutting short superficial inflammations, while it is of undoubted use when applied to the skin in sprains and other injuries of joints, or in injuries of the brain. In the latter cases it causes a contraction of the vessels without actually chilling the injured part. Cold is of no use in checking infective inflammations of any kind, its chief value being in limiting the simple traumatic inflammation following subcutaneous injuries. Its application must be *continuous*, or the periods of hyperæmia in the intervals between the cold applications will undo any good that may have resulted from the cooling. If the injury be not very severe, lint dipped in cold water, frequently renewed, may be applied; or, if the skin be unbroken, an evaporating alcoholic lotion may be used. Should a joint be severely injured, cold irrigation will be a preferable mode of applying cold. This may be done by suspending over the part a large wide-mouthed bottle full of water, in which a few pieces of ice may be put; one end of a skein of cotton, well wetted, is then allowed to hang in the water, whilst the other end is brought over the side of the bottle. This, acting as a siphon, causes a continual dropping upon the part to which the cold is to be applied.

But the direct application of pounded ice in a bladder or thin rubber bag is the most effectual means of applying cold, when it is intended that its effects shall penetrate deeply, as in an injured joint, spine, or head.

Another very efficient mode of applying cold is to surround the part with a coil of india-rubber tubing through which a stream of iced water is allowed slowly to flow from a reservoir placed above the bed. This method was introduced by Otis as a mode of applying cold to the genital organs, and for this purpose it is very efficient. When applied to the head or to a limb, the weight of the part is apt to compress the tube and arrest the flow. To overcome this difficulty, the apparatus known as "**Leiter's tubes**," made of soft metal which can be accurately applied to any part of the body, has lately been introduced. In using this the water must not be iced, as the greater conducting power of the metal renders this not only unnecessary but dangerous.

The application of a cold **Lead Lotion** acts as a powerful local sedative, and tends greatly to restrain local inflammation.

Absolute rest of the parts is an essential element in the preventive treatment of inflammation. Rest as to movement or use is imperative. An injured joint should be placed at rest on a splint; light should be excluded from an injured eye.

At the same time all constitutional disturbance must be prevented by a moderate and well-chosen diet, by repose of body, by regulation of the action of the bowels, and by careful attention to the hygienic surroundings of the patient.

Curative Treatment of Acute Inflammation.—In the curative treatment of inflammation the first object of the Surgeon is, if possible, to remove the cause, and to exclude every accessory source of irritation from the inflamed part. Thus, if there be an accumulation of septic matter, this must be removed, and the septic process checked by the use of antiseptics. If a foreign body be lodged in the flesh it must be extracted, and complete anatomical and physiological rest of the inflamed part must be ensured. At the same time the afflux of blood must, if possible, be kept within bounds, and blood-pressure reduced so as to limit the exudation and reduce tension. In attaining these objects constitutional and local means are made use of.

Local Treatment of Acute Inflammation.—**Position and Rest.**—The first step in the treatment of an inflamed part is to put it at perfect rest. All motion and use must be prevented, and, if necessary, restrained by splints and other appliances. If possible, the inflamed part should be elevated to a level with, or above, the rest of the body, in order to facilitate the return of blood, and thus to diminish congestion and reduce the blood-pressure in it, and thus lessen exudation and tension.

Cold and Heat are both used in the treatment of acute inflammation. The use of **Cold** in the prevention of inflammation has already been described (p. 213). When inflammation is fully established with its cardinal symptoms of redness, swelling, heat, and pain, cold should never be applied; as, although it may lead to a diminished flow of blood to the part by causing contraction of the arteries, it tends still further to lower the vitality of the affected tissues, and thus to increase the adhesion of the corpuscles and the retardation of the flow, till stasis, followed by death of the part, may result. Cold should never be had recourse to when suppuration is threatening or has set in; still less should it be employed when there is a tendency to mortification. The modes of applying cold have already been described (p. 213).

Warmth and moisture, conjoined, are of the utmost service in the treatment of inflammation during the height of that process—during that period when cold applications are not admissible. By these means the vessels are dilated to the fullest extent and the tendency to stasis diminished. The warmth tends also to hasten the return of vitality in the damaged area, if that be possible, and is, therefore, especially valuable in all cases in which there is a tendency to sloughing. The exudation from the distended vessels is increased, and it is believed that this tends to carry the migrated corpuscles out of the inflamed part into the lymphatics in those cases in which the irritant causing the inflammation is not of sufficient intensity to give rise to suppuration. It may also, by stimulating the activity of the migrated leucocytes, aid them in resisting the invasion of micro-organisms. Should suppuration be inevitable, warmth hastens the process by increasing the exudation and migration. Warmth and moisture, by causing relaxation of the parts, diminish tension and thus relieve pain.

When abscess threatens, and the skin is not broken, nothing affords so much relief as a well-made **linseed-meal poultice.** To make this smooth and soft, the meal must be gradually added to the proper amount of boiling water, being vigorously stirred at the same time. If the water be added to the meal, the mass is apt to become lumpy. It must be spread, not too thickly, on a piece of linen-rag, and applied as hot as the patient can bear it. It is better to use meal from which the oil has not been expressed, or to add to the ordinary linseed meal a small quantity of olive oil, which prevents its drying and sticking to the skin. But, useful as poultices are when the skin is unbroken, they are most objectionable when applied to a wound, ulcer, or granulating surface. Then they merely encourage putrefaction. In such cases **wet dressing**, consisting of a double or triple layer of common, or better boric, lint, moistened with a hot solution of boric acid, may be applied and covered with oiled silk extending half an inch to an inch beyond it on all sides. This may be covered with a thick layer of cotton-wool secured by a bandage. By these means we obtain an application which is cleaner and lighter than a poultice, and which retains its heat equally long. Another excellent substitute for a poultice is a sheet of salicylic wool (4 per cent.) about one inch thick, moistened with boiling water and covered with oiled silk and dry cotton-wool. This is also a most efficient antiseptic application.

Fomentations of warm water, or of decoction of poppy and camomile flowers, applied by means of flannels wrung out of these liquids, and applied hot, are very useful in extensive superficial inflammations. The flannels should be well covered with oiled silk or rubber cloth, so as to retain the heat and to prevent evaporation. Spongio-piline may be used as a substitute for flannel in cases in which the surface is unbroken.

Dry cotton-wool heated before a fire, applied warm, and covered with a large sheet of oiled silk, may sometimes be conveniently substituted for a fomentation. The watery vapour given off from the skin being enclosed by the oiled silk forms a sort of warm vapour bath for the affected part. Dry heat in the form of flannels, or bags of bran toasted before the fire, or heated in an oven, are often convenient applications, especially for the head or abdomen.

Belladonna, applied externally, sometimes exercises a very distinct influence over superficial inflammations of an acute and spreading character. It is

supposed to act partly by causing contraction of the small arteries by its direct action on the vaso-motor nerves, and partly by its sedative effect on the cutaneous sensory nerves, stimulation of which, as we have before seen, causes by reflex action a dilatation of the vessels in the area irritated. It is best applied, in conjunction with warmth and moisture, as a paint composed of equal parts of the extract and of glycerine, which may be smeared on the inflamed part and covered with cotton-wool, or hot fomentations. There is no danger of belladonna poisoning, even when large surfaces are painted with the extract and glycerine. I have frequently painted the whole arm in this way without any unpleasant effect; and the most I have ever noticed has been a little dryness of the throat after some days' use of the drug. The belladonna and glycerine must be carefully kept out of the way of children, as its taste is not unpleasant, and they are very likely to eat it by mistake for treacle. Two such cases have been admitted into University College Hospital, both of which fortunately recovered.

In superficial inflammations **Acetate of Lead** 4 grs., and laudanum 3 grs., to one ounce of water, diluted with an equal quantity of boiling water and applied hot on lint, will often be found a very useful application.

Local Blood-letting is an efficient means of lessening the congestion of an inflamed part, as by it in some cases we take blood directly from the distended vessels. It does not always act, however, quite so simply as this. In no disease is the benefit of local blood-letting more marked than in acute inflammation of the middle ear, and yet in this case we draw the blood from the cutaneous vessels of the mastoid process. In acute orchitis relief is often given by puncturing the distended veins of the scrotum, which have no direct connection with the swollen gland. In these cases the relief is probably due to a reflex contraction of the arteries leading to the inflamed part. The amount of blood taken in local blood-letting is not sufficient to have any influence on the general circulation.

Blood may be taken locally by *punctures*, *scarifications*, or *incisions*, or by *leeching* or *cupping*.

Punctures, scarifications, and **incisions** can be practised only in inflammation of the cutaneous and exposed mucous surfaces. They constitute a very efficient means of relieving the part, as not only is blood removed, but an exit is afforded for effused matters; tension is consequently materially lessened, and any tendency to sloughing diminished. There is no doubt also that in some infective inflammations they allow the fluids which are charged with the noxious products of the growth of the pathogenic organism to escape externally, instead of returning to the blood-stream, and thus materially relieve the constitutional disturbance. **Punctures** should be made with a fine lancet, in parallel rows over the inflamed surface, and should not exceed a quarter of an inch in depth. **Scarifications** are small and short incisions. They may be made across the congested vessels, which will bleed freely, as in the relief of a chemosis of the conjunctiva. A modification of puncture is sometimes practised by opening the veins in the neighbourhood of the inflamed part at several points, as in puncture of the scrotal veins, for inflammation of the testis.

When **incisions** are required they should be so arranged as to afford the greatest possible relief to the tension whilst doing the least possible mischief to the part incised. Their length and their depth must vary

according to the seat of the inflammation. Care must be taken as far as possible not to wound superficial arteries or veins of sufficient size to bleed dangerously.

Leeches may be applied to the neighbourhood of inflamed parts, but never upon the inflamed surface itself, as their bites irritate. There are certain situations in which leeches should not be placed, as over a large subcutaneous vein, or in regions where there is much loose areolar tissue, as the scrotum or eyelids, lest troublesome hæmorrhage or ecchymosis occur. So, also, they should not be applied near a specific ulcer, lest the bites become inoculated by the discharge. Should it be thought desirable to produce some constitutional effect, the bleeding may be encouraged by poultices or fomentations after the animal has dropped off. In this way from half an ounce to an ounce of blood may be taken by each leech. Owing to the fact that the leech secretes a material which prevents the coagulation of the blood, the hæmorrhage, which usually ceases spontaneously soon after the leech is removed, may continue for some time, and be difficult to arrest. Continuous pressure, the application of matico, or powdered alum, may then be tried, and if these fail—as may happen in some situations where pressure cannot be conveniently applied, as on the neck and abdomen, particularly in young people—a piece of nitrate of silver scraped to a point, or a heated wire introduced into the bite, previously wiped dry, or a needle transfixing the edges of the bite with a twisted suture over and around it, may be required.

Cupping may be either "wet" or "dry." Dry cupping consists in the application of the cupping-glasses to the skin without making any previous scarifications. It is a means of causing a determination of blood to the surface for the purpose of diminishing the flow to an internal organ. Thus in congestion of the kidneys following an operation on the urethra or bladder, dry cupping in the loins is often of use. The instruments required are a spirit lamp with a large flame, and the cupping-glasses. These are made of thick glass and are dome-shaped with smoothly-ground edges. The operation consists merely in rarefying the air in the cupping-glass by means of the flame of the spirit lamp, and instantly applying the glass firmly and evenly to the skin. The intention is not to heat the glass but the air contained in it, and in fact to a great extent to replace the air by the products of combustion of the flame of the lamp. It is for this reason that a large flame completely filling the glass should be used. If the operation be properly performed the site of the glass will be marked by a bruise due to the rupture of the capillary vessels in the area included in the vacuum.

In wet cupping the glass is applied in the same way over a number of superficial incisions which are made instantaneously by the "scarificator," an instrument provided with a number of parallel knives worked by a spring and released by a trigger. The quantity of blood extracted is regulated by the size of the glass, and the flow from the superficial wound ceases the moment it is removed. Cupping cannot be employed upon the inflamed surface itself, as it would be too painful, and is chiefly applicable to internal inflammations. As the scars made by the scarificators continue through life, cupping should not be practised upon exposed surfaces.

A modified form of cupping in which the vacuum is made by withdrawing a piston in a glass tube, or the *artificial leech*, as it is called, is not uncommonly used in ophthalmic practice.

Local blood-letting is now perhaps less used than it deserves to be. A few leeches give almost immediate relief to pain in many inflammations of the eye and middle ear and in simple inflammations of serous and synovial membranes. In acute infective inflammations they are evidently useless. They cannot arrest the growth of the micro-organisms which are causing the disease. It is therefore absurd to imagine that septic peritonitis following a wound of the abdomen can be influenced in any way by a handful of leeches drawing blood from the abdominal wall.

Cutting off the Supply of Blood from the inflamed part by the ligature of the main artery leading to it has been adopted in some cases. Thus, in acute inflammation of a joint, the main artery of the limb has been tied—the femoral, for instance, in inflammation of the knee-joint—but by most Surgeons the remedy would be considered worse than the disease.

Vanzetti recommended digital pressure on the arteries in inflammation. He has, for instance, related a case of severe acute inflammation of the hand, relieved by twenty-four hours' continuous pressure on the brachial artery. Neudörfer speaks highly of the proceeding, which he regards as surpassing all others in efficacy. It is applicable to inflammation of any part of which the artery is within reach.

Constitutional Treatment of Inflammation.—In the constitutional treatment of inflammation the Surgeon has various objects in view and must be influenced in the means he adopts by the general condition of the patient. In some cases it is his object to diminish the blood-pressure, in the hope of limiting exudation, by means calculated to reduce the force of the heart's action, as by general blood-letting or by the use of certain drugs. In other cases his chief object is to reduce the fever, especially when it assumes the sthenic type (p. 199), and when the opposite condition is met with his attention is chiefly directed to supporting the strength of the patient.

One of the most powerful means we possess of reducing the blood-pressure is **General Blood-letting**. When it was believed that acute inflammation was an active process which could be cut short by means calculated to reduce the strength of the patient, or, as it was termed, by **antiphlogistic treatment**, bleeding was the routine practice in all acute inflammatory diseases unless the age or weakness of the patient contra-indicated it. Now that we have a better knowledge of the nature and causes of inflammation, bleeding in surgical cases is almost completely abandoned. No one believes that the invasion of a pathogenic organism or putrefaction in a wound or cavity will be controlled in any way by bleeding; in fact, such treatment can only make the patient less able to resist the effects of the organisms and their products. The only surgical conditions in which blood-letting is of any service are: first, in certain cases of simple traumatic inflammation of the brain following laceration, in which the swelling of the cerebral substance is causing dangerous symptoms (see Chap. XXIV. Laceration of the Brain); secondly, in some cases of injury of the chest in which, owing to interference with respiration, the right side of the heart is overloaded with blood; thirdly, it is possibly useful in certain cases of internal hæmorrhage; and lastly, in some cases of internal aneurism. It will be observed that, only in the first of these is blood-letting used with the intention of limiting inflammatory exudation. The influence produced by blood-letting is judged of by the effect on the pulse, which should become softer and less tense. The frequency is not so much affected and

may even be reduced. It is always desirable to produce the necessary effect with the least possible loss of blood; hence the blood should be taken from a large orifice, the patient sitting upright. In repeating the venesection, we must be guided by the impression that has been made upon the disease, and by the state of the pulse. In former times, blood-letting from the temporal artery and the external jugular vein was sometimes practised; but, at the present day, blood is scarcely ever taken from any vessel but the median basilic vein at the bend of the elbow. The operation is thus performed: the region of the vein having been carefully cleaned with some efficient antiseptic and the patient being in a sitting posture, a tape or a piece of bandage is bound round the arm about midway between the shoulder and the elbow, with sufficient firmness to obstruct the return of blood through the veins, and yet not to interfere with the flow through the artery. When the limb below the bandage is fully distended with blood, the operator selects the most prominent vein at the bend of the elbow, which will almost invariably be the median basilic, and compresses it with his thumb *below* the point at which it is intended to open it; this serves the double purpose of steadying the vein and preventing a premature escape of blood. He then takes the lancet, or any other small sharp-pointed cutting instrument if a lancet be not at hand, and holding it by the blade between his forefinger and thumb, while he steadies his hand by resting the other fingers on the arm of the patient, he divides the skin and opens the vessel by a single incision about one-third of an inch in length, carried obliquely across the vein and dividing its anterior wall. He then takes a graduated vessel, and, holding it in such a position as to catch the blood, he removes his thumb from the vein, and allows the proper amount to escape. During the operation the patient should hold some round body in his hand, which he can grasp firmly at intervals; by this means the blood from the deep veins is driven out from amongst the muscles into the median by the communicating branch which enters it just before its bifurcation. As soon as a sufficient quantity of blood is drawn, the constricting band on the arm is relaxed; an antiseptic dressing of some kind is applied over the wound and secured by a few turns of a figure-of-8 bandage. The only accident that can happen during the operation is a wound of the brachial artery, which usually lies immediately beneath the median basilic vein near the point selected for bleeding. This is avoided by holding the blade of the lancet short and firmly, and supporting the back of the three inner fingers on the patient's arm: while by a movement of extension of the wrist, the point of the instrument is made to move in a segment of a circle, and so to open the prominent vein without any risk of penetrating more deeply than is intended. If from inadvertence the patient be bled in the recumbent position, a greater quantity of blood may be removed than is intended before the effect on the pulse is produced.

The only complication to be feared after the operation is septic inflammation of the vein, and although this is very rare it is sufficiently frequent to necessitate the careful use of antiseptics.

Bleeding from the external jugular vein should never be performed, as it is accompanied by the danger of entrance of air, and the effect produced differs in no respect from that of bleeding from the arm.

In inflammations of the head and chest a good effect may often be produced by *diverting the blood as much as possible to the lower extremities* by placing

them in hot water or by the application of elastic bandages in such a way as to engorge the limbs with blood.

We must in all cases endeavour to *set the secretions free*, and in this way to clear the blood of the morbid products accumulated in it. If we can obtain a copious bilious evacuation from the bowels or an abundant acid perspiration from the skin, or a copious discharge of urine, we shall diminish the constitutional disturbance and mitigate, if not cut short, the local process. With these objects in view, purgatives, diaphoretics, and diuretics are to be administered.

Purgatives, by causing dilatation of the vessels of the alimentary canal, reduce the blood-pressure in other parts, and this effect is still further increased by the diminution they cause in the general mass of the circulating fluid. Moreover, they clear the intestinal canal, and thus favour digestion and assimilation of food. From the frequency with which diarrhœa is associated with unhealthy inflammatory processes, it seems probable that the intestinal tract forms an important channel for the elimination of the products of such inflammations from the blood, and the necessity of maintaining a proper action of the bowels would thus be explained. Experience teaches us also that in inflammatory affections constipation always aggravates the elevation of temperature, and a brisk purgative will often bring it down one or two degrees. This is especially the case with children. Purgatives should, therefore, always be given early, except in some special cases of acute inflammation of the abdominal organs. In general, it will be found most advantageous to administer a mercurial, followed by a brisk saline purge; and this should be repeated from time to time during the progress of the case.

Diuretics and Diaphoretics are of much use when fever forms a marked feature of the case, and they should then be administered frequently during the day. Free perspiration lowers the temperature by increasing the loss of heat from the surface of the body and the dilatation of the cutaneous vessels tends to diminish the blood-pressure in internal parts. Both the skin and the kidneys also take an important part in the elimination of the products of the increased tissue-change which forms an essential feature in the febrile process; and, unless both perform their functions properly, these products may accumulate to a dangerous extent. The diaphoretics and diuretics most commonly used are citrate of potash, acetate of ammonia and nitrate of potash. *Antimony* in small and repeated doses was formerly much used partly with the intention of reducing the force of the heart's action and partly to induce sweating, when the skin was hot and dry. It may be given in the form of antimonial wine conjoined with the salines above mentioned, or as James's powder combined with Dover's powder, but if it be pushed too far, so as to induce nausea, it may seriously depress action of the heart, and consequently its effects must always be carefully watched.

Aconite in small doses frequently repeated—one minim of the tincture every half hour for four hours and then every hour—exercises a most marked influence on simple inflammatory fever with high temperature, but with no visceral complications. It lowers the force and frequency of the pulse and produces speedy and copious sweating, to the infinite relief of the patient.

Mercury was formerly much used, especially in acute inflammations of serous and fibrous membranes, not as a purgative but as an alterative, 'ed to a point just short of affecting the gums. It is not now given

in this way in acute inflammation. As a purgative its value cannot be overrated.

Opium is of essential service in allaying the pain and irritability that often accompany inflammation, especially in many affections of the bones and joints. Dover's powder is of especial value in this respect, and alone or combined with James's powder, forms one of the most powerful diaphoretics we possess.

Treatment of Inflammatory Fever.—The treatment of fever in surgical and medical cases is entirely different. The fever in the vast majority of surgical cases is due to the entrance into the blood-stream of some pyrogenic substance derived from a local source; such as an unhealthy wound, an unopened abscess, &c. In the treatment of the fever in such cases it is the duty of the Surgeon to seek the source of the pyrogenic material and to cut off the supply, as by opening the abscess, cleaning the foul wound or cavity, &c. In medicine unfortunately the physician is as a rule unable to do this, and consequently has to fall back on drugs, a practice which the Surgeon should only adopt as a last resource.

The treatment of fever must necessarily vary with the type it assumes, whether it is *sthenic* or *asthenic* (p. 199). In all forms the patient must be put to bed and kept warm and quiet. The diet must be light but nutritious; beef-tea, veal, mutton, or chicken broth, bread and farinaceous puddings being the chief constituents. During high fever the patient has no appetite for solid food, nor could he digest it, but eggs and milk can often be taken. The eggs must be raw or very lightly boiled, and may be beaten up with the beef-tea or milk. Milk should always be boiled, and it will be found in many cases very useful to add a very small quantity of arrow-root, which makes the curd less lumpy in the stomach and more easy of digestion. The thirst from which the patient suffers is often best relieved by lemon-juice and soda-water with little or no sugar, or by dilute phosphoric acid in the proportion of about one drachm to one pint of water sipped occasionally, or aromatic sulphuric acid in about the same dose. The patient's mouth should always be carefully cleaned several times a day with an antiseptic fluid of some kind, such as peppermint water, spirits of juniper largely diluted with water, boric acid lotion, Condy's fluid, &c. The foul mouth in fever is one of the patient's greatest sources of discomfort. In order to keep the skin clean and active the body should be daily washed with warm water, only a small part being exposed at one time, so as to avoid cold.

If the fever assume the *sthenic form*, with a full and bounding pulse and a high temperature with headache, and possibly delirium, as a rule no alcohol is required, although sometimes it may help in reducing the temperature and promoting sleep. The patient's bowels must be kept open and diaphoretics administered as already described. It is in these cases that specific drugs may be used, supposing the Surgeon cannot arrest the fever by cutting off the supply of the pyrogenic substance entering the blood-stream. The antipyretics most commonly employed are quinine in large doses, salicylate of soda, and the various coal-tar derivatives known as antipyrin, antifebrin, and phenacetin. Of these, quinine and salicylate of soda have been credited with some power of destroying, or at least inhibiting, the growth of micro-organisms in the body, but the evidence as to this is not satisfactory. All except quinine are extremely depressing drugs, causing profuse perspiration, and must be administered with

great caution, especially in cases of severe surgical injury. Phenacetin is said to be least likely to be followed by unpleasant consequences. Of all these drugs, quinine is the most practically useful in surgical cases, and no artificial product has yet been found to equal it.

An ice-cap to the head will be found of great use in many cases. It helps to reduce the temperature and relieves the headache. In extreme cases of hyperpyrexia, which are rare in surgical practice, wet-packing or cold baths may be employed to reduce the temperature, should their use not be contra-indicated by the nature of the injury or by some visceral complication.

When the fever assumes the *asthenic type* in a surgical case, either from the beginning or as a sequel of the sthenic form, it is always due to some general infective process or to absorption of septic matter. This form is predisposed to by the broken state of the constitution, from drinking, poverty and foul air, so commonly met with in the patients in a London hospital. In such cases any so-called antiphlogistic treatment is evidently out of place, and all depressing antipyretics should be avoided. The bowels must be cleared out and diaphoretic salines may be given. Carbonate of ammonia in doses of from three to five grains in decoction of cinchona is often useful. Quinine in five-grain doses, repeated four times a day, may be of use, especially in the fever of pyæmia and septicæmia. The diet must be as nourishing as the patient can take, and of the character before described. It is in this form of fever that alcohol is of the greatest use. This is not the place to enter into a discussion of the much-disputed question whether alcohol can act as a food. There is no doubt that it enters the blood unaltered, and that in some way it disappears from the body when the amount given is moderate in amount. When an excessive quantity is administered, it appears unchanged in the breath, sweat and urine. Doubts have been raised as to its combustion in the body because there is no increase in the carbon dioxide given off by the respiration after its administration. No other mode of elimination has, however, been demonstrated, and it is quite reasonable to suppose that the absence of any increase in the carbon dioxide expired may be due to the diminished oxidation of other substances in the body during the time that the alcohol is being consumed. One thing, however, is quite certain, and that is, that if we desire alcohol to act as a *food only* in producing energy by combustion, it must be given in very small doses, such as a teaspoonful of brandy, very frequently repeated, as there is no mechanism by which it can be stored in the body. If half an ounce of strong spirit be given in a single dose, some is lost by the breath and skin, and the heart is stimulated to excessive action, thus wasting the force it is our desire to conserve. On the other hand, it is sometimes our object to "whip up" the heart, especially when there is a tendency to passive congestion and stasis, as in hypostatic pneumonia; in that case a periodical large dose of alcohol, or perhaps of ether, will produce the desired effect.

The proper use of alcoholic stimulants in fever is a most difficult problem. The popular notion that alcohol "gives strength," and that the more you can give to an exhausted patient the better, has not one atom of evidence to support it. It is very rarely that a patient is really benefited by more than eight ounces of good brandy per diem, and care must be taken that it is not given in such an amount as to extinguish whatever appetite may

remain for ordinary food. When the patient can take it, porter or stout may be given, as they contain much genuine food in addition to the alcohol. When the patient is recovering, alcoholic stimulants with the meals often increase the enjoyment of food and promote digestion, especially in those accustomed to their use.

The asthenic type of fever, formerly so common, is not now so often met with in hospital practice. In a certain proportion of cases the constitutional state of the patient is such that any inflammatory process will certainly assume this type, but in the majority of cases the special constitutional state is secondary to an unhealthy septic or infective process going on at the seat of inflammation. By the prevention of these unhealthy processes by the modern treatment of wounds, and by the improvement of the general hygienic conditions of our hospitals, much has been done to prevent the occurrence of the worst form of asthenic inflammatory fever.

Chronic Inflammation.—The foregoing description has referred solely to acute inflammation, and it now remains to give a brief summary of the distinctive characters of the chronic form of the process.

It is commonly said that chronic inflammation, although differing from the acute form in its course, symptoms and effect, is but a modification of the same process. This is no doubt true of many forms between which and the acute process no sharp line can be drawn, but a large number of pathological changes which are described as chronic inflammation differ so widely from the acute process that it is difficult to see any point of analogy between them. In acute inflammation the original tissues are passive during the acute stage of the process, the cells infiltrating the part being all migrated leucocytes, and it is not till the tissues are recovering from the damage they have suffered that proliferation of the original cells commences. In many pathological processes classed under the heading of Chronic Inflammation new growth from the original tissues forms the sole phenomenon, and there is no evidence of migration of leucocytes at any stage. Between these two extremes every gradation is met with, and it is common to find migration of leucocytes and destruction of tissue going on side by side with proliferation and growth, and the two processes are often so intermixed that it is often impossible to determine, with any degree of certainty, the origin of a large proportion of the new cells infiltrating a chronically inflamed area. This combination of the two processes is due to the fact that chronic inflammation is the result of irritation of a low and frequently varying degree of intensity acting for a prolonged period of time, and, as has already been pointed out, the same cause which, acting intensely, may give rise to acute inflammation and even to death, acting less powerfully may stimulate the original cells of the part to proliferation and growth. In no chronic inflammatory process is there any permanent increase in the more highly differentiated structures. For example, in chronic inflammation of a gland, the glandular epithelium degenerates, while the interstitial tissue increases, and in the central nervous system the nerve-cells degenerate as the connective tissue increases. Surface epithelium such as that of the skin or mucous membrane frequently hypertrophies in chronic inflammatory processes, and in the growth of new connective tissue new vessels are often formed, but the new connective tissue as a rule becomes dense and scarlike, and compresses the higher tissues amongst which it is developed. It is always devoid of yellow elastic tissue. In all chronic inflammations any new tissue that forms

is of low vitality and readily degenerates, and the chronic process may often be intensified to the acute from a comparatively slight increase in the local irritation.

Widely, therefore, as chronic inflammation may differ from the acute process, there are points in which an analogy may be traced between them. In acute inflammation the essential features are a diminution of the vital activity of the tissues, and of the walls of the vessels consequent upon some injurious influence acting upon them. This is followed by dilatation of the vessels with exudation of almost pure blood-plasma, and migration of leucocytes which infiltrate the damaged area, while at the same time changes of a degenerative or destructive character take place in the original tissues of the part. In chronic inflammation all these phenomena may occur, but they are less strongly marked. They may conveniently be considered in the same order as in the acute process.

The dilatation of the vessels and afflux of blood are much less. The chronic distension, however, lasting as it may do for an indefinite period, leads to a permanent loss of tone and dilatation, especially in the small veins, which, in chronically inflamed parts, can often be seen clearly with the naked eye. The relaxation of the arteries is less complete, and there is often a tendency to slackened circulation. The redness, when present in chronic inflammation, is therefore as a rule more dusky than in the acute form. The whole process being due to a slighter degree of damage to the tissues, there is not the same impairment of vitality in the walls of the vessels, and consequently the tendency of the corpuscles to adhere to the vessels and retard the flow is little marked. Migration when it does occur is usually less abundant, and probably is influenced by the conditions described on p. 161. The vessels in most cases still retain to some extent their selective influence on what passes through their walls, and the exudation in chronic inflammations is less rich in albumen and often not spontaneously coagulable. Thus in chronic inflammations of serous or synovial cavities, we frequently find them distended with a fluid of considerably lower specific gravity than that of the liquor sanguinis, and not possessing the power of spontaneous coagulation. In those chronic inflammations which are partly caused by prolonged passive congestion, red corpuscles are frequently found outside the vessels.

The tissues of a part affected by chronic inflammation become, as in the acute process, crowded with new cells, the probable origin of which has already been mentioned. These new cells show the same phagocytic properties as those met with in acute inflammation. They take an active part in the destruction and absorption of dead or degenerating tissues, as, for example, the osteoblasts in chronic inflammation of bone, and in infective inflammations caused by invading organisms they are often found to have surrounded the pathogenic fungi, or to have taken them into their substance, as is seen in the giant cells of tubercle.

The new cells produced in chronic inflammation undergo a variety of changes according to circumstances. If the part recovers, they may, as in acute inflammation, disappear, probably disintegrating or being absorbed, or possibly, if still possessing amœboid properties, wandering away into the lymphatics. It is rare, however, for perfect recovery to follow chronic inflammation; most commonly some thickening or induration from newly-formed fibrous tissue is left behind.

In other cases the cells may go on proliferating, slowly destroying or dis-

placing the surrounding tissues till they form a mass, often of considerable size, as in some forms of chronic inflammation of the synovial membranes of joints; in these masses of cells new vessels are formed, but the vascularisation of the new growth is always more or less imperfect, so that degenerative changes early set in for want of sufficient supply of nutriment. Thus, in chronic tuberculous inflammation of joints, we may find, replacing the synovial membrane, a soft pulpy mass of tissue, perhaps an inch in thickness. The layer of this, in nearest relation to the vessels of the surrounding healthy structures, is moderately supplied with new vessels, and presents the ordinary appearances of healthy granulation-tissue; next to this is a layer containing few vessels, and lastly, we find a layer in which the cells have perished from want of blood supply. If they are still recognisable as cells, they are withered and shrunken and filled with fat-granules; but usually they are in part at least reduced to a granular mass, in which no individual elements are any longer to be seen. This change is known as "*caseation*." The fatty layer may soften and break down into a fluid, which somewhat resembles pus in appearance, but on microscopic examination is found to contain few, if any, pus-cells. The collection of fluid thus formed is a *chronic* or *cold abscess*.

Another fate that may befall the accumulations of cells formed as a consequence of chronic inflammation is, that after undergoing complete fatty degeneration, the mass so formed may become dry and cheesy by the absorption of its fluids The dry cheesy masses thus formed may remain in this state for an indefinite period, but at any time they may soften from causes as yet but imperfectly understood. In the process of softening, the cheesy matter undergoes chemical changes which give it irritating properties; and, as the result of this, inflammation of a more acute character with suppuration may be set up, leading to ulceration in the tissues surrounding it, or to the formation of an abscess which finds its way to the surface, and thus the caseous matter may be eliminated from the body.

Another change, the reverse of softening, may take place, when the mass is of small size; it may shrink and dry up more completely, and lime-salts may be deposited in it, forming a chalky concretion, which remains permanently unchangeable and harmless. Chronic inflammation, with caseation of the inflammatory products often followed by softening, are of frequent occurrence in lymphatic glands, bones, and the subcutaneous tissue; calcification is occasionally met with in bone, and is very common in the lymphatic glands. Both processes are very frequently the result of tubercle, but are by no means exclusively caused by it. Both caseation and calcification are met with in chronic endarteritis; in the syphilitic gumma a fatty degeneration closely resembling the caseation of tubercle occurs; typical calcification is met with in the chronic inflammatory tissue surrounding a hydatid cyst or enclosing a trichina spiralis, and many other examples might be given.

Chronic inflammation gives rise to yet another change, differing essentially from those already described, viz. to an overgrowth of the connective-tissue of the affected part, or fibrous hyperplasia. In many organs and tissues the new fibrous tissue causes an induration to which the term "sclerosis" is applied. This forms the most marked feature of many forms of chronic inflammation, as in chronic interstitial inflammation of glandular organs, chronic osteitis and periostitis, chronic arteritis, and chronic inflammatory affections of the skin. Many of these affections are so far removed from

inflammation in their clinical features, that some pathologists have hesitated to apply that term to them. But they resemble inflammation in being the result of irritation, and in being characterised by a diminished vitality of the affected part, as indicated by the readiness with which a slight injury converts the chronic process into an acute inflammation of the ordinary type. Microscopic examination of tissues or organs from different cases affected in this way shows every possible variation between the infiltration of the connective tissue with innumerable small round cells indistinguishable from the wandering leucocytes of acute inflammation, and the development of a tissue composed of dense rigid-looking fibres between which are found a few elongated cells. In fact, no sharp line can be drawn between acute interstitial inflammation and the chronic form with fibroid induration. In bone, chronic inflammation of this type is shown by thickening of the periosteum and formation of new bone beneath it, by increased density or sclerosis of the compact tissue, with narrowing or obliteration of the Haversian canals, or by condensation of the cancellous tissue. In arteries, the growth takes place chiefly from the outer layer of the inner coat, and the new tissue closely resembles the old in structure. This form of chronic inflammation is, as a rule, accompanied by more or less atrophy and degeneration of the higher tissues, their place being occupied by the overgrown connective-tissue, and for this reason it has been spoken of as a "fibroid substitution."

Another common effect of chronic inflammation is *ulceration*. Except in the slowness of its progress it differs in no respect from that occurring in acute inflammation. The tissues first become infiltrated with new cells, which accumulate and press on the original structures, finally destroying them and taking their place. Then in their turn the destroying cells perish, break down, and come away mixed with serous exudation as pus; and thus a gradual progressive destruction of tissue takes place. *Suppuration* often assumes a chronic form, as in the case of large abscesses proceeding from the thorax or abdomen, or from deeply-seated diseased joints or bones. The natural tendency of all abscesses, as soon as they are opened, is to fill up with granulation-tissue and to close; but when there is some source of irritation present, as decomposing matter, tension from imperfect drainage, or friction of one surface against another, the granulations break down into pus as quickly as they grow, and the process may thus be prolonged indefinitely, the only limit being the powers of endurance of the patient.

In chronic inflammations, although the connective-tissue may, as before described, undergo an increased development, the higher tissues always suffer degenerative changes—partly as a result of the pressure to which they are exposed from the new growth. Thus the tubules or acini of a chronically inflamed gland become obliterated, and muscular fibre in an inflamed muscle undergoes fatty degeneration. In this way the functional activity of organs suffering from chronic inflammation is more or less interfered with.

Thus we see that chronic inflammation, although differing widely from acute, does present some analogies to it. The development of increased connective-tissue is analogous to the adhesive or productive form of acute inflammation, and the formation of a cheesy centre, or a chronic abscess, differs chiefly in its chronicity from the process by which an acute abscess arises, while ulceration and some forms of suppuration are the same processes in both forms of inflammation, differing only in their rate of progress and duration.

No sharp line can be drawn between chronic and acute inflammations; and the term "**subacute**" is often used to signify processes in the border-land between the two.

Chronic inflammations, like the acute, may be *simple* or *infective*. Syphilis, tubercle and leprosy are examples of infective diseases of which chronic inflammatory processes form the essential pathological features.

Causes.—The causes of chronic inflammation are like those of the acute process, predisposing and determining. The **predisposing causes** are the same as those of acute inflammation; anything that tends to lower the vitality and interfere with healthy nutrition, either generally or locally, predisposes to one as much as to the other. Perhaps *passive congestion* forms the most common of all predisposing causes, and it is often difficult to draw a distinct line between the non-inflammatory changes, the induration and pigmentation resulting from congestion, and those produced by true chronic inflammation. Certain congenital or hereditary constitutional states form important predisposing causes, the most important of these being probably the condition commonly known as *scrofula* or the *scrofulous diathesis*. This is sometimes defined as a predisposition to tubercle in all its forms, but probably Virchow's definition of scrofula as an "abnormal vulnerability of the tissues" is the best. It is a condition of low vitality in which the tissues do not offer the normal resistance to external injurious influences of all kinds. Scrofulous subjects offer a feeble resistance to the invasion of all parasites, not only to the tubercle bacillus. (*See* Chapter on Tubercle and Scrofula.) Amongst the acquired constitutional conditions, *syphilis, rheumatism* and *gout* form frequent predisposing causes; so much so that in all chronic inflammations it is the duty of the Surgeon to bear in mind the possibility of one of these being present. The importance of the predisposing causes is undoubtedly relatively greater in the chronic than in the acute form of the inflammatory process, and this fact must be borne in mind in the treatment of the affection.

The **immediate causes** of chronic inflammation are of the same nature as those of the acute process, but they act with a less degree of intensity and more continuously. So long as the cause of the inflammation is present the process cannot subside. In chronic inflammation it often happens that the cause which starts the process is of a temporary character, the persistent effect being due to other causes which come into play at a later period. Thus in a common ulcer of the leg the history of the case is frequently as follows: The patient, possibly ill-nourished and feeble from want of proper food, suffers from varicose veins, which interfere with the return of blood from the skin of the leg, giving rise to a condition of passive congestion. As a result of this the skin of the leg is badly nourished and of low vitality, and incapable of withstanding the effects of even mild degrees of irritation. Sooner or later some slight injury, such as a scratch or blow, which would be harmless to healthy tissues, gives rise to inflammation of sufficient intensity to reach the stage of suppuration. The pus raises the cuticle, forming a small pustule which bursts, leaving a raw surface beneath. The discharge decomposes and irritates the surface, the clothes rub the ulcer, the muscles working beneath in walking move it about, the dilatation of the vessels and the exudation, added to the obstruction in front which originally gave rise to the congestion, produce tension; and all these causes combined, maintain the inflammatory process, the suppuration continues, and the sore slowly spreads by ulceration.

In such a case as this the predisposing cause, and the secondary causes, play by far the most important part, and the exciting cause that started the process may be so slight as almost to escape notice.

In many cases the nature or quantity of inflammatory products serves partly as a cause of the persistence of the process. Thus in the case of inflammation of the synovial or serous membranes, the tension caused by the effusion of fluid is sufficient to maintain the inflammatory process long after the original cause of mischief has been removed. In other cases, in which formation of new tissue is an important element in the process, the feebleness of the new growth, its imperfect development, or its insufficient vascularisation make it unable to withstand slight sources of irritation; and thus causes which would be harmless to healthy tissues perpetuate the inflammatory process in the new growth; or the new tissue may perish and, acting as a foreign body, excite inflammation in the tissues in contact with it.

In the chronic infective inflammations the essential cause is a specific virus. In tubercle it has been proved to be a specific organism—the tubercle bacillus. But granting this, it must not be forgotten that numerous accessory causes play a most important part in the development of tuberculous diseases. Hereditary tendency, bad hygienic surroundings, bad feeding, impaired health from other diseases as measles or whooping-cough, and local damage, may all act as predisposing causes, and not only is the development of the disease determined by these causes, but the course it follows is influenced in no less degree. Whether the chronic inflammatory process set up by the presence of the bacillus remains local or becomes general, whether it causes fibrous hyperplasia, caseation and softening with chronic suppuration, or whether its progress is rapid or slow, does not depend upon any variation in the essential cause, the bacillus, but in the accessory causes, such as the degree of rest given to the affected part, the general health and the hygienic surroundings.

In syphilis the nature of the poison is not known. In the early stages the virus itself seems to be the essential cause of the chronic inflammatory processes which form the pathological features of the disease, but after this stage has subsided there seems sometimes to be left behind an impairment of the constitution in which chronic inflammatory processes are readily induced, but in which there is no evidence of the presence of a virus communicable to another individual. Thus syphilis may be both a predisposing, and a determining cause of chronic inflammation.

Local Signs.—The modifications of colour, size, sensation, function and temperature, described as attendant on acute inflammation, are present also in chronic inflammation; differing, however, in origin and in degree, and often in order and combination. The *colour* is not always changed, unless the part affected be very superficial; and the redness is rather of the dull than of the bright hue, not depending on the rapid transmission of an increased quantity of bright blood, but rather on a congestive condition. The affected tissue may become permanently discoloured by the escape of large numbers of red blood-corpuscles, which break up and are imperfectly absorbed, leaving the pigment behind. The *pain* is not often spontaneously acute, but partakes generally of the character of tenderness, being elicited only by pressure; sometimes, however, the pain is very severe. The increase of *temperature* is usually wanting, [illegible]ever great. *Swelling* is an early and most important sign in chronic [illegible]on. It depends less on the enlargement of the vessels than on the

effusion which takes place, and the production of new tissue which often constitutes the distinctive characteristic of the disease. The *impairment of function* is constantly present as in acute inflammation, but to a very varying degree.

CONSTITUTIONAL SYMPTOMS.—These are less marked in chronic than in acute inflammation. The patient is in most cases, however, in impaired health; being, in many instances, affected with some constitutional taint which has had its influence in producing or maintaining the chronic character of the inflammation. In all cases in which there is chronic suppuration, and in most of the chronic infective inflammations, the pulse will be found to be above the normal standard, and slight febrile disturbance, often of a distinctly periodic character, is usually present. In these cases the temperature should be closely watched, and a rise towards evening especially noted as an important indication of a smouldering inflammatory process.

TREATMENT. CONSTITUTIONAL.—In chronic inflammation, the so-called antiphlogistic treatment is never required. Local nutrition is always deeply modified in chronic inflammation; and it can be restored to its normal condition only by improving the patient's general health, and at the same time producing an impression on the part itself by appropriate topical means. Hence, in the treatment of chronic inflammation, hygienic measures are of the first consequence. The treatment of this form of inflammation must likewise be varied according as it is uncomplicated, occurring in an otherwise healthy constitution; or as it assumes a congestive or passive character in a cachectic and feeble system; or as it is met with affecting a specific form in an unhealthy constitution.

In the majority of chronic, as of acute inflammations, it is necessary to give rest to the affected part, as in white swelling of a joint, or disease of the vertebræ, but as a rule confinement to bed should be avoided if possible. The patient should be in pure air; sea-air being especially useful in all tuberculous inflammations. The patient should be warmly clothed. The action of the bowels should be regulated, if necessary, by purgatives. Attention to the **diet** is of great importance; it should in all cases be light and unstimulating, sufficient in quantity, but not excessive.

Alcohol is very rarely required in the treatment of chronic inflammations; in fact, as its abuse is one of the most common predisposing causes of such affections, it is more commonly necessary to restrain the patient from its use than to encourage him in it. In tuberculous disease of any kind its use is only required when it encourages the appetite and aids digestion, and then it should be taken only with meals. The practice of giving such patients a glass of wine once or twice a day between meals to "keep up their strength" cannot be too strongly condemned. It does not really give strength, and the habit is apt to grow upon the patient during a long illness, and may become extremely troublesome. A little warm beef-tea or soup, or a cup of properly made tea will usually produce the desired effect more safely. In chronic suppuration with great exhaustion, as in the asthenic form of inflammatory fever, stimulants may be required. In gouty inflammations, and in most of those due to rheumatism, wine and beer should be avoided; distilled alcoholic drinks only being allowed, and those only in small quantities with meals. When, as is so often the case, the chronic inflammation is due to some definite constitutional affection, such as gout, rheumatism, or syphilis, the general treatment

is of even greater importance than the local, and must of course be directed to the special condition ; as, for example, saline purgatives and colchicum for gout, salicylate of soda for rheumatism, and mercury and iodide of potassium for syphilis.

Cod-liver oil, which may be regarded rather as an article of diet than a medicine, is often of the greatest value in strumous inflammations, especially in children and young people, when debilitated, emaciated or cachectic. It should always be given after meals, and when anæmia is present, it may be advantageously conjoined with the preparations of iron, such as Steel-wine, the Syrup of the Iodide of Iron, or the Compound Syrup of the Phosphate of Iron (Parrish's chemical food), or the Syrup of Iron, Quinine and Strychnine (Easton's Syrup).

Mercury, given in small doses for a considerable length of time until the gums are slightly affected, is often of use, even in cases not definitely syphilitic in origin. It seems, in some cases, to hasten the absorption of the exudation and to aid in removing thickening, or sclerosis of the affected part. It should, however, on no account be given in cachectic or strumous constitutions, or for tuberculous disease of any kind. The perchloride in doses of one-sixteenth to one-twelfth of a grain may be given, conjoined with iron or cinchona if the patient's general health is somewhat depressed.

Iodide of potassium is an alterative and absorbent of the greatest value, especially in the chronic inflammations of fibrous or osseous tissues, or of the glands, occurring in strumous constitutions. In many cases it is of essential service after a mercurial course.

Various **natural sulphur waters,** such as those of Harrogate in England, Aix-la-Chapelle in Germany, Aix-les-Bains in Savoy, and the baths of the Pyrenees, especially Barèges, have always enjoyed a great reputation in the treatment of chronic inflammations, whether syphilitic, rheumatic or strumous. The treatment consists in hot bathing, combined with the internal administration of the waters. In syphilitic diseases mercury is given at the same time by inunction.

The **sulphides of calcium and potassium,** especially the former, given in small doses, have been recommended by Ringer as a substitute for the natural sulphur waters. He states that they are particularly useful in the chronic inflammations of scrofulous subjects, when there is a tendency to caseation of the inflammatory products, and slow elimination by softening and suppuration. In such conditions they hasten the process and shorten the course of the disease. Ringer recommends for a child a mixture of much the same strength as the Harrogate waters—viz. one grain of the sulphide of calcium dissolved in half a pint of water, and of this one teaspoonful may be taken hourly. In adults, in whom this mode of administering medicine is seldom possible, a pill containing one-quarter to one-third of a grain of the sulphide may be taken three times a day.

Other **mineral waters,** taken internally or used as baths, deservedly enjoy a great reputation in the treatment of many chronic inflammatory affections, the particular bath to be recommended depending upon the constitutional condition which forms the predisposing cause of the disease. Thus for anæmia and general debility iron waters, such as those of Tunbridge Wells in England, the Kniebis baths in the Black Forest, or Schwalbach ; for scrofulous affections, iodine waters, such as those of Kreuznach ; for gout,

alkaline waters, such as those of Vichy in France, or purgative waters, such as Carlsbad, or neutral waters, such as Bath, Baden-Baden, or Homburg; and for rheumatism, Buxton and Bath. In many chronic diseases of joints, hot salt baths, either of sea-water, artificial solution of salt or the natural brine springs of Droitwich, are very useful.

LOCAL TREATMENT OF CHRONIC INFLAMMATION.—In chronic inflammation, our local means of treatment are much more varied than in the acute form of the disease.

Local Blood-letting is scarcely ever useful in chronic inflammations.

Warmth and Moisture are not so serviceable in chronic as in acute inflammation, and care should be taken that they be not continued for so long a time as to make the parts sodden. An astringent or stimulant, such as liquor plumbi or spirits of wine, may often advantageously be added to the warm application.

In many chronic inflammations recovery is delayed by the passive congestion which so often accompanies the process. In these cases, although the part may possibly always contain an excess of blood, it circulates too slowly, and consequently there is really a diminished supply. Many of the most important means of treating chronic inflammation are intended to empty the congested vessels, and to cause an afflux of blood and a hastening of the circulation through the affected part, stimulating the tissues in the normal processes of absorption and repair. Thus **Cold**, not applied continuously as in acute inflammation, but for a short time twice or thrice a day, by douching with cold water, is often of great use. It first tends to cause a contraction of the vessels, which, perhaps, by calling them actively into play, exercises them as it were, and tends to restore their healthy tone; and this is followed by dilatation, with an increased flow of blood through the affected part, thus improving the nutrition of the tissues and hastening their repair. A somewhat similar effect may be produced by the use of **Electricity**, in the form of the continuous current; but perhaps the most useful of these modes of treatment is **Rubbing**, or **Massage.** Rubbing acts in several ways. First, it mechanically empties a congested part of blood, causing a fresh flow to it, and thus promotes healthy nutrition; secondly, the mechanical stimulus causes a contraction of the muscular coats of the vessels followed by a relaxation, thus exercising them and aiding in restoring their normal tone; thirdly, if properly applied, it empties the lymph-spaces, and thus aids in relieving the part of serous or inflammatory exudation; fourthly, it stimulates the contraction of muscles which have been thrown out of work (as in the case of an inflamed joint), and thus maintains their nutrition; and, lastly, it helps to break down adhesions amongst contiguous structures.

Rubbing must be done with sufficient force to produce the desired effect, but not so violently as to injure the skin. A skilful rubber can do this without greasing the hand, but usually it is better to use a little oil. If it be desired to produce a greater afflux of blood, some stimulating liniment may be used, but this is not usually of any great advantage. The time for which the rubbing should be kept up varies with the case from a quarter to half an hour or more. The more chronic the case, the longer will the rubbing be required. Rubbing is chiefly applicable to chronic inflammations of joints, synovial membranes and muscles, and it is undoubtedly one of the most efficient means of treatment that we possess. A large amount of training and

experience is required to produce a perfect rubber, one, for instance, who can pick out the individual muscles and stimulate them to contraction; but, fortunately, such high art is seldom required. In the majority of cases, a few lessons will enable anyone gifted with ordinary intelligence to rub a chronically inflamed part with sufficient skill to produce some good effect. The points to be attended to are to rub always in the direction of the circulation, not up and down as is commonly done; to use the right amount of force, and yet not to make the skin sore, and to rub for a sufficient length of time. That a trained *masseur* is in every way superior to an unskilled amateur need not be said, and wherever it is possible to obtain the services of a professional rubber it is wise to do so, but in private practice in the country, and amongst the poor, such a luxury is not to be had, and much good may be done even by an amateur.

Counter-Irritants are local applications which give rise to irritation of the skin of varying intensity according to their nature, the mildest forms, as a camphor liniment, causing merely a passing dilatation of the cutaneous vessels, and the most severe, as the actual cautery, producing destruction of the skin and even of part of the subcutaneous tissue. The value of counter-irritants is recognised by all practical Surgeons, and they are undoubtedly amongst the most effective local means that we possess for combating chronic inflammation: yet their mode of action is difficult to explain. The old theory that by exciting a local inflammation in the skin it was possible to draw the disease away from the deeper and more important parts is no longer tenable; the theory that by stimulation of the sensory nerves of the skin a dilatation of the superficial vessels is produced, accompanied by a corresponding contraction in the deeper parts, cannot be supported by scientific evidence; in fact, as Billroth has pointed out, it is probable that in many cases, especially in extremely sluggish chronic inflammations, the good produced is probably rather by an increased afflux of blood to the affected part than by a diminution of the blood supply. Most counter-irritants are applied solely with the intention of causing a certain degree of hyperæmia or of inflammation in the part of the skin on which they are placed, while others exert, or are supposed to exert, at the same time a constitutional effect, being absorbed into the system from the cutaneous surface. Counter-irritants are classed according to the degree of local irritation they give rise to.

Rubefacients are those that cause merely a dilatation of the vessels of the part to which they are applied, such as camphor liniment, mustard poultices, Rigollot's mustard leaves, capsicum plasters, &c. In surgery, they are chiefly used in rheumatic inflammations of muscles or nerves.

Vesicants are those applications which cause a degree of inflammation sufficient to give rise to abundant exudation, which raises the corneous layer of the cuticle from the Malpighian layer beneath, thus forming a bleb or blister. Vesicants are extensively used in surgery to promote absorption of the products of chronic inflammation, and in some cases to check the process, as in the application of blisters in chronic synovitis or periostitis, or to the perineum in chronic prostatitis.

The preparations of cantharides are the chief blistering agents employed; of these the two most common are the Emplastrum Cantharidis, or common fly-blister, and the Liquor Epispasticus. The former is applied to surfaces free

from hair, the latter to the scalp or perineum. In applying a blister, or the liquor epispasticus, it is essential that the part should be as free from grease as possible, and for this purpose it must be washed with soap and hot water, and afterwards, if it can be conveniently done, sponged over with a very dilute solution of ammonia, before the blister is put on. The blister should rise in from eight to twelve hours. When the bleb is fully formed, if it is not intended to prolong the action, it should be carefully pricked with a needle, but the cuticle should not be removed. It should then be covered with cotton-wool and a bandage, or a little simple ointment on a piece of linen. If it be desired to prolong the counter-irritation, the cuticle may be removed, and the raw surface dressed with savin ointment, by which means it may be kept open as long as is wished.

A blister does not, as a rule, leave a scar; but it may do so, and it is well therefore not to apply it to the face or hands if this can be avoided. The extent of surface to which it is applied must not exceed a few square inches, for there is some danger of the absorption of the cantharidine, and of consequent congestion of the kidneys, hæmaturia, and strangury. This will of course happen more readily if there be a raw surface beneath the plaster. Blisters must always be used with great caution in very old or feeble subjects, and in those suffering from Bright's disease, or any other serious visceral affection, as in such cases they occasionally cause sloughing.

Suppurants or **Pyogenic counter-irritants** are those agents which are of sufficient intensity to give rise to inflammation reaching the stage of sup-

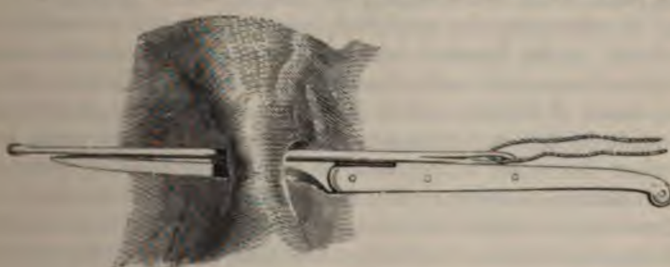

Fig. 87.—Introduction of a Seton.

puration. The most common of these are croton oil, issues, setons, and the actual cautery. An *issue* was a suppurating sore, made with a caustic and kept open by savin ointment, or a pea put in the middle of it and retained in position by plaster. A *seton* consisted of a few threads of silk passed under a fold of skin, in the way shown in Fig. 87. The suppurating track was often kept open for many months. Both these modes of treatment are now abandoned.

The **Actual Cautery** is very successful in chronic inflammation of joints before destruction of the cartilages has set in, and it is especially useful when there is great pain with nocturnal startings. The relief given by it is often immediate and permanent. In the application of the cautery it is the object of the Surgeon to destroy the cuticle and the tips of the papillæ, but to leave the deeper structures of the skin uninjured, so that there shall be no contraction of the scar when the sore has healed.

For this purpose the cauterising iron should be of a dull red heat, and must

be quickly drawn in lines crossing one another over the part. Paquelin's Thermo-Cautery is on the whole the most manageable and the cleanest form that can be used. The barbarous application known as a *moxa*, which consisted of cotton or pith soaked in saltpetre and allowed to burn upon the skin, is now no longer used in this country.

Two counter-irritants in addition to their local action produce constitutional effects when absorbed from the surface to which they are applied—viz. Iodine and Mercury.

Iodine is most commonly applied in the form of tincture; it should be painted over the inflamed part twice a day till the skin becomes a little sore. This may be continued for weeks or months according to circumstances. It is no doubt a useful means of promoting the absorption of chronic inflammatory products, but the powers popularly ascribed to it are certainly far greater than it really possesses. The liniment is less frequently used, being a much stronger preparation, one application of which will often cause vesication. The iodine or iodide of lead ointment may be applied in cases in which a somewhat stronger action than that of the tincture is desired, but they are not cleanly applications, and are not usually to be recommended.

Mercury is applied locally in many forms to promote the absorption of the products of chronic inflammation and in the treatment of the process. One of the most common modes of applying it to chronically inflamed joints is in the form of "Scott's dressing." This consists in spreading a thin layer of the compound mercurial ointment on a piece of lint of sufficient size to surround the joint. Over this strapping is evenly applied so as to exert a uniform pressure. In other cases the mercurial liniment or simple mercurial ointment may be of use. John Marshall introduced an elegant preparation composed of the precipitated mercuric oxide dissolved in oleic acid. There is thus formed a definite oleate of mercury which is soluble in an excess of oleic acid. A solution made in this way containing five per cent. of the oxide is a clear liquid; when the oxide is increased to twenty per cent. it forms a solid unctuous substance, melting readily at the temperature of the body. As the oleate of mercury is slightly irritating to the skin, one grain of morphia may be added to each drachm. Marshall states that his experience of the use of this preparation in all forms of chronic inflammation has been very favourable. It is cleaner, more diffusible, more readily absorbed, and more efficacious than any other mercurial application. The very fact, however, that it is so readily absorbed forbids our using it in scrofulous subjects, who always stand mercury badly. Ten to thirty drops of the oleate, melted if necessary by a very gentle heat, and applied with a camel's-hair pencil, are quite sufficient for one application.

Astringents applied directly to the inflamed parts are of the greatest service in those forms of congestive or passive inflammation in which the circulation is sluggish and the capillaries loaded; they afford relief in these cases by inducing contraction of the vessels. In order to ensure their proper action, they must be employed of sufficient strength; for if too weak they irritate, and increase rather than relieve the congested condition. The nitrate of silver is the astringent that is commonly preferred; this may be applied either solid or in a solution containing from ten grains to one drachm of the salt in one ounce of distilled water, and will produce a very marked beneficial influence in congestive inflammation of mucous, and occasionally of cutaneous, surfaces.

Pressure by means of well-applied bandages, elastic webbing, or strapping, is of essential service in supporting the feeble vessels in congestive inflammations. In many cases pressure may be advantageously conjoined with absorbents and rubefacients, as mercurial and camphor liniments, or the plaster of mercury and ammoniacum. This treatment, by removing congestion, and promoting the absorption of inflammatory effusion, is especially useful in chronic forms of inflammation accompanied by thickening of parts, as in the joints and testes.

CATARRHAL INFLAMMATION.

Catarrh or catarrhal inflammation is a form of the process of inflammation affecting mucous membranes and other epithelium-covered surfaces. All these are liable like other structures to traumatic inflammations of the ordinary type, in which, as a consequence of the action of some irritant, the vessels dilate, the circulation is retarded, the white corpuscles migrate and the liquor sanguinis exudes, and the functional activity of the original cells is suspended or permanently abolished. The peculiarity of the catarrhal form, however, consists in the fact that, although the vessels are dilated and exudation of blood-plasma and even the abundant escape of white corpuscles is taking place, yet the epithelium continues to exist and perform its function, and in most cases its cells multiply with unnatural rapidity. Catarrh may arise from the direct application of an irritant to the surface of the mucous membrane, as in the case of decomposing urine irritating the bladder or of gonorrhœal pus acting on the urethra. At first sight it seems difficult to explain why in these cases the vessels of the corium and the submucous tissue should show signs of damage, by their giving exit to an abundant exudation and by the white corpuscles passing through their walls, while the epithelium is comparatively uninjured, showing signs rather of stimulation than of impaired function. It must not be forgotten, however, that surface-epithelium is a structure which possesses in a high degree the power of resisting external injurious influences; and it is quite conceivable, therefore, that a cause which exerts no more than a stimulating action on the epithelium may, if it penetrate to the parts beneath, give rise to the phenomena of inflammation.

In other cases the cause of catarrh is not so clear, as when a patient is attacked by bronchitis, catarrhal nephritis, or cystitis, as the result of "catching cold." In these cases it is probable that the contraction of the cutaneous vessels causes hyperæmia of the internal organs, but hyperæmia alone is not sufficient to cause catarrh; probably the inflammation is due in part, at least in the case of the lung and kidney, to increased work thrown upon these organs in the elimination of those products of tissue-change which should be given off by the skin. Our knowledge is not, however, as yet sufficient to explain rationally the origin of all catarrhal inflammation.

The changes in the affected membrane depend on the degree of the process. In the mildest form there is some swelling due to exudation of serum. This partly distends the loose submucous tissue, and drains off by the lymphatics, and partly flows away from the surface of the membrane. At the same time the cells of the epithelium multiply more quickly than natural, and many are loosened and come away with the discharge. If this loss of epithelium is very considerable the process is described as *desquamative catarrh*. In all

be q ... ..ation of mucus during catarrh.
Ther ... marked clinical feature of the
that
siste ... **purulent catarrh**, the vessels
is n ... ..dely dilated and the flow through
... copious, and the white corpuscles
eff ... thus leave the vessels, wander
and ... the natural cohesion of which is
... ace, forming with the liquid exuda-
pa ... in such a case, if examined micro-
so ... rous amœboid cells, presenting the
It ... ..les; ordinary pus-cells, round and
... epithelium-cells, some fully developed
... ..tural to the affected membrane, some
... ..y developed, and others containing a
... A microscopic examination of a section
... ..f the abundant discharge of pus, there
... ..overed by epithelium. The wandering
... the vessels and immediately beneath the
... ..-cells will be found to contain within
... pus-corpuscles. These were supposed by
... ..rulent catarrh was formed by endogenous
... ..ells. Later observations, however, have
... mother-cells are in reality dead or dying
... ..enetrated by wandering leucocytes. Wan-
... ..trating between the individual epithelium-
... ..flammation, as, for example, in gonorrhœa.
... the process are found in the epithelium and

... inflammation there need be no ulceration.
... readily one process may be converted into
... ..thelium-cells to each other, and to the corium,
... severe forms of catarrh; should the loosely
... ..ntally removed by violence from without, or
... ..ation beneath, a small ulcer will be the result.
... ..arrh, like other forms of inflammation, may
... ..nic form is very frequently associated with
... ..ected. It may also be *simple*, as in bronchitis,
... ..hthalmia or gonorrhœa. The thick muco-
... on the surface of a mucous membrane during
... ..s as a nidus for the growth of microscopic
... ..e changes these set up give rise to products
... ..n and cause it to spread almost indefinitely.
... affected surface, with slight swelling and an
... ..m a pure serous to a thick muco-purulent fluid,
... features of a catarrhal inflammation. The heat
... ..s not a marked symptom except in the more
... ..thalmia. The constitutional symptoms vary
... ..ss and the part affected. As a rule, only the
... ..ve rise to any elevation of temperature. The

absence of fever may possibly be accounted for by the fact that the exudation drains away from the surface and but little finds its way back into the blood-stream.

Parts which have suffered from chronic catarrh, or from repeated attacks of the acute form, usually become more or less pigmented, and the sub-mucous tissue is thickened and indurated. These signs are well seen in the mucous membrane of the bladder in cases of old stricture or stone.

The **treatment** of catarrhal inflammation presents little that requires special notice. In the more acute forms warmth and moisture, and above all removal of the discharge and prevention of its decomposition, form the most important means of treatment. Belladonna is often of use locally in diminishing pain and promoting contraction of the small arteries. In chronic catarrh, removal of the secretion and cleanliness with the use of astringents, and antiseptics, such as nitrate of silver, acetate of lead, sulphate of copper or tannin, boric acid, iodoform, &c., form the chief treatment. Any constitutional condition such as scrofula or gout must be searched for and treated.

CHAPTER V.

SUPPURATION AND ABSCESS.

SUPPURATION, or the formation of pus, has already been described in Chapter on Inflammation. It was there pointed out that the process con of a continuance and exaggeration of one of the features of inflammation– migration of the white corpuscles. The process of suppuration may be dif or circumscribed. When diffuse, the leucocytes and the liquid exudation dist the lymph spaces of the affected part without the formation at first of any tinct cavity containing pus, as in phlegmonous erysipelas or diffuse cellul This, as will be seen afterwards, is due to the rapid diffusion of the irri causing the suppuration through the lymph spaces. Circumscribed suppura may occur in two forms, first from a surface, as a granulating wound, secondly subcutaneously, when the pus accumulates in a newly-formed ca or abscess.

In the formation of an acute abscess the wandering cells accumulate out the vessels, and possibly multiply by division in their new situation, but is extremely doubtful; as the accumulation increases, the original tiss already damaged by the irritant which is causing the inflammation, bec pressed upon and absorbed, and the new cells occupy their place; finally, central cells of the group degenerate from want of nutrition, or perish from direct action of the irritant, their intercellular substance softens, and liquid exudation from the surrounding part soaks in amongst them, and we get a creamy fluid, or pus.

If, as sometimes happens, we have the opportunity of examining microsc cally such a small collection of pus in the subcutaneous tissue, the follov appearances are observed, proceeding from the circumference to the centr the affected area. The first sign of deviation from health is that some scatt leucocytes are seen in the spaces between the fibres of the connective tis and often evidently in the neighbourhood of a small vessel; as the cent approached, the number of these increases, gradually obscuring the connec tissue and its corpuscles, till at last nothing is to be seen but closely-pac small round cells, between which the amount of intercellular substance is small to be recognised; in the centre of this group of cells may be a ca from which the pus has escaped in preparing the section. Amongst the clos packed cells surrounding the collection of pus, micro-organisms can alı invariably be demonstrated by proper staining and preparation of the specir The connective tissue, when it is last recognisable before being concealed the infiltrating leucocytes, is seen to have its fibres swollen and vitreou appearance, while its corpuscles are unchanged or degenerating. T evidently are taking no part in the formation of the new cells which crowding amongst the fibres. If any blood-vessels are recognisable, it wi seen that, near the point at which everything is concealed by the leucoc they are filled with closely packed blood-corpuscles, indicating the presence

clot. It is in this way that they are closed before, in common with the other tissues, they soften and break down in the presence of the invading leucocytes, and thus hæmorrhage is prevented. In this area also, although it cannot be seen with the microscope, the plasma which has exuded from the vessels is coagulated, and with the migrated cells forms a firm substance, the so-called inflammatory lymph, which fills and plugs the spaces of the connective tissue, and thus forms a barrier round the collection of pus, and prevents its diffusing itself amongst the tissues around. It is not possible in a section made from a preparation removed from the body to observe the state of the vessels beyond the area of stasis or thrombosis; but if we could observe them in the living body we should see, in a spreading abscess, all the conditions already described

Fig. 88.—A Microscopic Abscess in the Skin. *e.* Epithelium; *h.* a Hair; *v. v.* Small Veins surrounded in some places by migrating leucocytes; *p.* the collection of pus; *s.* Sweat-gland; *h.* a small Artery; *f.* Fat. The Tissues round the collection of pus are dotted with leucocytes becoming more closely packed as the centre of suppuration is approached.

under Inflammation: viz. from the centre towards the circumference, stasis, oscillation, dilated vessels with retarded flow, adhesion of the corpuscles, and migration, and lastly, simple hyperæmia, — dilated vessels with increased rapidity of flow. Such a collection of pus as is above described is a microscopic abscess; an acute abscess, holding half a pint, differs from it only in size. The extension of the abscess takes place by progressive destruction of the tissues by the same process; and the pus is formed by successive zones of the new cells degenerating, becoming separated from each other by fluid, and falling into the cavity. In this way the collection of pus advances towards a free surface and finally discharges itself. This "pointing of the abscess," as it is termed, advances most rapidly in the direction of least resistance, probably because the migration of the leucocytes and dilatation of the vessels occur more readily on that side. The whole process is identical with ulceration,

but instead of the discharge being given off superficially as in an ordinary ulcer, it accumulates in the abscess-cavity; an abscess is in fact a cavity enclosed by an ulcer. The zone of tissue in which the process of spreading is taking place was in former times spoken of as the "pyogenic membrane;" but it is evident that there is nothing to which the term "membrane" could properly be applied: the "pyogenic zone" would be a more correct term if any such is necessary. In this pyogenic zone the vessels are dilated and the tissues softened, so that in opening an abscess blood may flow freely from the engorged vessels round the cavity: but it must not be concluded from this that the abscess-cavity is surrounded by a zone of tissue in which new vessels have been formed. During the spreading stage of an abscess, it is destruction of vessels, not new formation, that is taking place; the new formation occurs only during repair, after the pus has been let out.

The method in which pus is formed on mucous surfaces in purulent catarrh has been described with that process.

That all the pus-cells in acute suppuration are derived from the white corpuscles may now be regarded as an established fact. The proof of this is derived partly from the direct observation of the formation of pus, as it has already been described, and partly from the experiments of Cohnheim, Von Recklinghausen, and others. These observers injected aniline blue or cinnabar into the blood-stream of the animal to be experimented on. It had before been shown that when solid matter in a state of extremely fine division is injected into the blood-stream, the white corpuscles pick up the particles in the same way as an amœba takes its food; and the dark-coloured particles of aniline blue or cinnabar are easily recognised in their substance. A frog having been prepared by the injection of the colouring matter, inflammation of sufficient intensity to cause suppuration was excited; and it was found that, whether it was in a vascular part or in a non-vascular, as the cornea, the pus-cells contained particles of the substance which had been injected.

Lastly, there is the negative observation, that in acute inflammations the original cells of the affected part undergo no change so long as they can be observed; that is to say, before they are concealed by the crowds of migrating leucocytes.

In the case of chronic suppuration from the surface of a healing ulcer the purulent fluid must contain many of the superficial granulation-cells which have perished and been cast off. These, as we shall see in the Chapter on Repair, are probably derived from the original cells of the affected part, and are practically indistinguishable from pus-cells derived from migrated corpuscles. This may, however, be regarded rather as an accident than as a part of true suppuration.

Characters of Pus.—The pus from an acute abscess is an opaque, creamy fluid, thick, smooth, and slightly viscid, of a yellowish-white colour, with in some cases a greenish tinge; it has a faint odour and an alkaline reaction. Its specific gravity is from 1030 to 1040. Its chemical constitution varies slightly in different cases. It contains from 85 to 90 per cent. of water. Dried pus contains on an average about 67 per cent. of proteids, chiefly identical with those found in white blood corpuscles, 14 per cent. of fatty matter, half of which is lecithin; about 7 per cent. of cholesterin, and 10 of [illegible]ctives, and 2 per cent. of salts. The chief inorganic constituents are [illegible] chloride, calcium, magnesium, and ferric phosphates; calcium phos

phate is said to be more abundant in pus coming from bone, but this is doubtful—there is merely a trace of potassium. The serum separated from the corpuscles contains about 90 per cent. of water. Of the solid constituents over 6 per cent. are proteids; not more than ·15 per cent. lecithin and other fats; and about ·8 per cent. salts, chiefly sodium chloride. It will be seen, therefore, that the lecithin and other fatty matters are chiefly contained in the corpuscles. Pus contains no fibrinogen, but fibrin-ferment has been shown to be present in it. The absence of fibrinogen in pus is most easily explained by supposing that the exudation from the vessels first coagulates in the zone in which the liquid pus has not yet formed, and then softens and breaks down. In addition to the above constituents, peptones and albumoses are found, formed under the influence of the micro-organisms which are constantly present in all acute suppurations. Leucin, tyrosin, and various less important substances are also often found in pus. Pus also frequently contains the specific virus of the disease with which its formation is connected, as in small-pox, glanders, tetanus, soft chancres, gonorrhœa, &c. The organisms specially connected with suppuration will be described later on. Many of the chemical substances found in pus have intense fever-producing (pyrogenic) powers if injected into the blood-stream.

Pus presenting the above characters is termed healthy or laudable pus (*pus bonum et laudabile* of the old writers), but various other terms are employed to indicate different appearances: thus, when tinged with blood it is called *sanious;* when thin and watery, *ichorous;* when containing cheesy-looking flakes, *curdy;* and when diluted with mucus, *muco-pus*. Besides these, pus presents other varieties; thus, for instance, when it is formed in the brain it is of a greenish tint, and when in the neighbourhood of the alimentary canal it has a peculiar, fetid odour.

Pus is a liquid which readily putrefies when exposed to the air or mixed with water at the temperature of the body, or even if septic organisms be introduced subcutaneously, as by an aspirator-needle or trochar. Thus we occasionally see that a collection of pus which, when tapped for the first time, is free from putrefaction, becomes offensive in a few days unless proper antiseptic precautions are taken during the operation. In some rare cases the pus, soaking a dressing, assumes a distinctly blue colour from the development in it of a special form of organism, the bacillus pyocyaneus. Blue pus is never found in a freshly opened abscess.

Microscopic Characters.—Pus consists of corpuscles floating in a clear fluid, the "liquor puris." In pus drawn from an acute abscess or from the surface of a healthy granulating sore, living cells, presenting amœboid movements if examined on a warm plate, and dead cells which have undergone degenerative changes, are met with, the latter being the true pus-cells, and by far the more abundant. The living cells are mono-nucleated and poly-nucleated leucocytes, and have already been described (*see* Migration of the Leucocytes). The typical "pus-cells" are the dead or degenerating leucocytes. They are rounded in form and slightly irregular in outline, and measure about $\frac{1}{2500}$-inch in diameter, and their protoplasm is coarsely granular, so that the nucleus is completely concealed. By treating with dilute acetic acid the granules are to a great extent dissolved, the protoplasm becomes swollen, and the nucleus comes clearly into view. It is then seen to be composed usually of three, sometimes of four or two parts, usually devoid of nucleoli

(Fig. 89). This breaking up of the nucleus has usually been regarded as a part of the degeneration of the migrated leucocyte, as the nucleus does not present the peculiar appearances observed in multiplication of cells by division of the nucleus (*karyokinesis*). On the other hand, as before stated (p. 163), Metchnikoff asserts that the greater number of migrating leucocytes are polynuclear at the time of migration, when they are manifesting their amœboid and phagocytic properties with the greatest activity. In addition to the granules, which can be cleared up by acetic acid, pus-cells contain a varying number of fat granules formed by fatty degeneration of the protoplasm. These may be so abundant as to conceal the nucleus after the addition of acetic acid. They are dissolved by ether and liquor potassæ. The older the pus the more complete is the fatty degeneration and the less the nucleus can be stained by logwood or aniline dyes. Finally, in old collections of pus the cells may break up completely and the granules float free in the liquor puris. It is usually possible to demonstrate the presence of micro-organisms not only free in the liquor puris but in the protoplasm of the pus-cells; the more degenerate the cells the more difficult it is to do this. In the pus of acute abscesses granular *débris* derived from the broken-down tissues are usually present, and fibres of yellow elastic tissue, which are the most resisting of all, may sometimes be recognised.

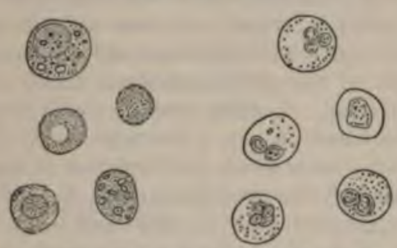

Fig. 89.—Pus-cells from Acute Abscess, before and after treatment with acetic acid.

Diagnosis of pus from other fluids must be made by the microscope. The presence of the characteristic pus-cell above described is certain proof that the fluid in question is composed in part at least of pus.

The relation of Micro-organisms to Suppuration.—It was first shown by Alexander Ogston, of Aberdeen, that the pus of all acute abscesses contains micro-organisms, and his observations have been extended by Rosenbach, Koch, and a large number of other observers, until it may be said now to be an accepted fact that all acute suppurations with which the Surgeon has to deal, whether superficial or deep, are associated with the presence of micro-organisms. The investigation of this subject has been carried out in three ways :—First, by the direct observation of properly stained and prepared specimens of pus ; secondly, by the cultivation of the organisms in solid or in liquid media ; and lastly, by the inoculation of animals, and, in some cases, of the human subject, with the organisms derived from pus.

The important subject of the relation of micro-organisms to suppuration is best considered under six headings. First, a description of the organisms most commonly met with in acute suppuration ; secondly, the proof of the pyogenic properties of the organisms ; thirdly, the mode of action of the organisms and the part they take in causing suppuration ; fourthly, can suppuration occur without the intervention of micro-organisms ? fifthly, can simple septic bacteria give rise to suppuration ? and lastly, what accessory causes commonly aid in the causation of suppuration ?

The examination of pus for microscopic organisms has been rendered so simple by the methods introduced by Weigert, and perfected by Koch, and the

interest attaching to the subject is so great, that it may be well here briefly to describe the process. The reagents required are, a solution of methyl-violet (one of the aniline dyes), of the strength of half a grain to one ounce of distilled water, carefully filtered, and some pure Canada balsam, which has been heated to drive off its volatile oil. The method of observation is as follows: Spread the pus on a glass cover-slip in the thinnest possible layer, and dry it carefully over a spirit-lamp, taking care not to overheat it; dip a clean glass rod in the methyl-violet solution, and spread a thin film of the dye over the dried layer of pus; after from thirty to sixty seconds, wash the dye off carefully with a gentle stream of distilled water. A darkly-stained film should remain behind, which must be again dried over the spirit-lamp; then while the cover-slip is still warm, put on it a drop of the Canada balsam, rendered fluid by heat, and place it quickly on a glass slide which is also slightly warmed; squeeze it gently down, and when cold it is ready for examination. The micrococci are distinguished from other granules by their definite round form and uniform size, and by their arrangement in groups or chains. They, moreover, take the dye readily, while fatty and albuminoid granules remain uncoloured. Blood or urine may be examined by the same process.

There are, of course, many other methods of staining and preparing organisms, but the above will be found practically efficient for the ordinary pyogenic organisms.

The Chief Micro-organisms connected with Acute Suppuration.—In about 70 per cent. of all acute subcutaneous suppurations the organism present is a micrococcus (see p. 178) belonging to the group *Staphylococcus*, so named from the separate cells being heaped together in irregular masses resembling a bunch of grapes (Fig. 90). Staphylococci grow well at ordinary temperatures on nutrient gelatine, agar-agar and potatoes. When grown on gelatine they gradually liquefy it, and at the same time a slightly sour smell is given off. They generate no gas in their growth, and can either derive the oxygen from the air or from the tissues or fluids in which they may be growing in the body, that is to say, they can be aërobic or anaërobic, according to circumstances. Two chief varieties are commonly met with, *Staphylococcus pyogenes aureus* and *albus*. They are only distinguished by their growth on the various cultivating media, the aureus forming colonies of a golden-yellow colour, and the albus forming opaque white patches. The two forms are frequently found together in the same abscess, and are probably mere varieties of the same species. In rare cases another variety forming lemon-coloured colonies has been met with, and has received the name of *Staphylococcus pyogenes citreus.* The staphylococci give rise to localised suppurations, and show no tendency to diffuse themselves widely by the lymph spaces. On the other hand, they frequently penetrate the small vessels of the part in which they are growing, and

Fig. 90.—Pus from Acute Abscess, containing the Staphylococcus pyogenes.

mucous membranes there is an exaggerated formation of mucus during *catarrh*, and this increased secretion forms the most marked clinical feature of the milder form of the affection.

In more intense catarrhal inflammations, or **purulent catarrh**, the vessels of the corium of the mucous membrane are widely dilated and the flow through them is retarded; liquid exudation is more copious, and the white corpuscles migrate abundantly. The leucocytes, which thus leave the vessels, wander amongst and through the epithelium-cells, the natural cohesion of which is somewhat loosened, and escape on the surface, forming with the liquid exudation a purulent discharge. The discharge in such a case, if examined microscopically, will be found to contain—numerous amœboid cells, presenting the usual appearance of white blood-corpuscles; ordinary pus-cells, round and granular, with the tripartite nucleus; and epithelium-cells, some fully developed and corresponding in form to that natural to the affected membrane, some of rounded form, young and imperfectly developed, and others containing a large transparent globule of mucus. A microscopic examination of a section of the membrane shows that, in spite of the abundant discharge of pus, there is no raw surface; everywhere it is covered by epithelium. The wandering cells can be seen in the corium round the vessels and immediately beneath the epithelium. Some of the epithelium-cells will be found to contain within them several bodies identical with pus-corpuscles. These were supposed by Rindfleisch to show that the pus in purulent catarrh was formed by endogenous cell formation from the epithelium-cells. Later observations, however, have tended to prove that these apparent mother-cells are in reality dead or dying epithelium-cells, which have been penetrated by wandering leucocytes. Wandering leucocytes are also found penetrating between the individual epithelium-cells. In some forms of catarrhal inflammation, as, for example, in gonorrhœa, the micro-organisms which cause the process are found in the epithelium and pus-cells.

Although in purulent catarrhal inflammation there need be no ulceration, the above description shows how readily one process may be converted into the other. The adhesion of the epithelium-cells to each other, and to the corium, is always loosened in the more severe forms of catarrh; should the loosely adherent epithelial layer be accidentally removed by violence from without, or separated by exaggerated cell-migration beneath, a small ulcer will be the result.

Varieties of Catarrh.—Catarrh, like other forms of inflammation, may be *acute* or *chronic*. The chronic form is very frequently associated with passive hyperæmia of the part affected. It may also be *simple*, as in bronchitis, or *infective*, as in purulent ophthalmia or gonorrhœa. The thick muco-purulent secretion that forms on the surface of a mucous membrane during a simple catarrh frequently serves as a nidus for the growth of microscopic organisms, and the fermentative changes these set up give rise to products which may prolong the irritation and cause it to spread almost indefinitely.

Symptoms.—Redness of the affected surface, with slight swelling and an abundant secretion varying from a pure serous to a thick muco-purulent fluid, form the most marked clinical features of a catarrhal inflammation. The heat is usually moderate, and pain is not a marked symptom except in the more acute forms, as in purulent ophthalmia. The constitutional symptoms vary with the acuteness of the process and the part affected. As a rule, only the most acute forms of catarrh give rise to any elevation of temperature. The

absence of fever may possibly be accounted for by the fact that the exudation drains away from the surface and but little finds its way back into the blood-stream.

Parts which have suffered from chronic catarrh, or from repeated attacks of the acute form, usually become more or less pigmented, and the sub-mucous tissue is thickened and indurated. These signs are well seen in the mucous membrane of the bladder in cases of old stricture or stone.

The **treatment** of catarrhal inflammation presents little that requires special notice. In the more acute forms warmth and moisture, and above all removal of the discharge and prevention of its decomposition, form the most important means of treatment. Belladonna is often of use locally in diminishing pain and promoting contraction of the small arteries. In chronic catarrh, removal of the secretion and cleanliness with the use of astringents, and antiseptics, such as nitrate of silver, acetate of lead, sulphate of copper or tannin, boric acid, iodoform, &c., form the chief treatment. Any constitutional condition such as scrofula or gout must be searched for and treated.

CHAPTER V.

SUPPURATION AND ABSCESS.

SUPPURATION, or the formation of pus, has already been described in Chapter on Inflammation. It was there pointed out that the process cons of a continuance and exaggeration of one of the features of inflammation— migration of the white corpuscles. The process of suppuration may be dif or circumscribed. When diffuse, the leucocytes and the liquid exudation dist the lymph spaces of the affected part without the formation at first of any tinct cavity containing pus, as in phlegmonous erysipelas or diffuse cellul This, as will be seen afterwards, is due to the rapid diffusion of the irri causing the suppuration through the lymph spaces. Circumscribed suppura may occur in two forms, first from a surface, as a granulating wound, secondly subcutaneously, when the pus accumulates in a newly-formed ca or abscess.

In the formation of an acute abscess the wandering cells accumulate out the vessels, and possibly multiply by division in their new situation, but is extremely doubtful; as the accumulation increases, the original tiss already damaged by the irritant which is causing the inflammation, bec pressed upon and absorbed, and the new cells occupy their place; finally, central cells of the group degenerate from want of nutrition, or perish from direct action of the irritant, their intercellular substance softens, and liquid exudation from the surrounding part soaks in amongst them, and we get a creamy fluid, or pus.

If, as sometimes happens, we have the opportunity of examining microsc cally such a small collection of pus in the subcutaneous tissue, the follow appearances are observed, proceeding from the circumference to the centr the affected area. The first sign of deviation from health is that some scatt leucocytes are seen in the spaces between the fibres of the connective tis and often evidently in the neighbourhood of a small vessel; as the cent approached, the number of these increases, gradually obscuring the connec tissue and its corpuscles, till at last nothing is to be seen but closely-pac small round cells, between which the amount of intercellular substance is small to be recognised; in the centre of this group of cells may be a ca from which the pus has escaped in preparing the section. Amongst the clos packed cells surrounding the collection of pus, micro-organisms can aln invariably be demonstrated by proper staining and preparation of the specin The connective tissue, when it is last recognisable before being concealed the infiltrating leucocytes, is seen to have its fibres swollen and vitreou appearance, while its corpuscles are unchanged or degenerating. T evidently are taking no part in the formation of the new cells which crowding amongst the fibres. If any blood-vessels are recognisable, it wi seen that, near the point at which everything is concealed by the leucoc they are filled with closely packed blood-corpuscles, indicating the presence

clot. It is in this way that they are closed before, in common with the other tissues, they soften and break down in the presence of the invading leucocytes, and thus hæmorrhage is prevented. In this area also, although it cannot be seen with the microscope, the plasma which has exuded from the vessels is coagulated, and with the migrated cells forms a firm substance, the so-called inflammatory lymph, which fills and plugs the spaces of the connective tissue, and thus forms a barrier round the collection of pus, and prevents its diffusing itself amongst the tissues around. It is not possible in a section made from a preparation removed from the body to observe the state of the vessels beyond the area of stasis or thrombosis; but if we could observe them in the living body we should see, in a spreading abscess, all the conditions already described

Fig. [illegible].—A Microscopic Abscess in the Skin. *e.* Epithelium; *h.* a Hair; *v. v.* Small Veins surrounded in some places by migrating leucocytes; *p.* the collection of pus; *s.* Sweat-gland; *h.* a small Artery; *f.* Fat. The Tissues round the collection of pus are dotted with leucocytes becoming more closely packed as the centre of suppuration is approached.

under Inflammation: viz. from the centre towards the circumference, stasis, oscillation, dilated vessels with retarded flow, adhesion of the corpuscles, and migration, and lastly, simple hyperæmia,—dilated vessels with increased rapidity of flow. Such a collection of pus as is above described is a microscopic abscess; an acute abscess, holding half a pint, differs from it only in size. The extension of the abscess takes place by progressive destruction of the tissues by the same process; and the pus is formed by successive zones of the new cells degenerating, becoming separated from each other by fluid, and falling into the cavity. In this way the collection of pus advances towards a free surface and finally discharges itself. This "pointing of the abscess," as it is termed, advances most rapidly in the direction of least resistance, probably because the migration of the leucocytes and dilatation of the vessels occur more readily on that side. The whole process is identical with ulceration,

but instead of the discharge being given off superficially as in an ordinary ulcer, it accumulates in the abscess-cavity; an abscess is in fact a cavity enclosed by an ulcer. The zone of tissue in which the process of spreading is taking place was in former times spoken of as the "pyogenic membrane:" but it is evident that there is nothing to which the term "membrane" could properly be applied: the "pyogenic zone" would be a more correct term if any such is necessary. In this pyogenic zone the vessels are dilated and the tissues softened, so that in opening an abscess blood may flow freely from the engorged vessels round the cavity; but it must not be concluded from this that the abscess-cavity is surrounded by a zone of tissue in which new vessels have been formed. During the spreading stage of an abscess, it is destruction of vessels, not new formation, that is taking place; the new formation occurs only during repair, after the pus has been let out.

The method in which pus is formed on mucous surfaces in purulent catarrh has been described with that process.

That all the pus-cells in acute suppuration are derived from the white corpuscles may now be regarded as an established fact. The proof of this is derived partly from the direct observation of the formation of pus, as it has already been described, and partly from the experiments of Cohnheim, Von Recklinghausen, and others. These observers injected aniline blue or cinnabar into the blood-stream of the animal to be experimented on. It had before been shown that when solid matter in a state of extremely fine division is injected into the blood-stream, the white corpuscles pick up the particles in the same way as an amœba takes its food; and the dark-coloured particles of aniline blue or cinnabar are easily recognised in their substance. A frog having been prepared by the injection of the colouring matter, inflammation of sufficient intensity to cause suppuration was excited; and it was found that, whether it was in a vascular part or in a non-vascular, as the cornea, the pus-cells contained particles of the substance which had been injected.

Lastly, there is the negative observation, that in acute inflammations the original cells of the affected part undergo no change so long as they can be observed; that is to say, before they are concealed by the crowds of migrating leucocytes.

In the case of chronic suppuration from the surface of a healing ulcer the purulent fluid must contain many of the superficial granulation-cells which have perished and been cast off. These, as we shall see in the Chapter on Repair, are probably derived from the original cells of the affected part, and are practically indistinguishable from pus-cells derived from migrated corpuscles. This may, however, be regarded rather as an accident than as a part of true suppuration.

Characters of Pus.—The pus from an acute abscess is an opaque, creamy fluid, thick, smooth, and slightly viscid, of a yellowish-white colour, with in some cases a greenish tinge; it has a faint odour and an alkaline reaction. Its specific gravity is from 1030 to 1040. Its chemical constitution varies slightly in different cases. It contains from 85 to 90 per cent. of water. Dried pus contains on an average about 67 per cent. of proteids, chiefly identical with those found in white blood corpuscles, 14 per cent. of fatty matter, half of which is lecithin; about 7 per cent. of cholesterin, and 10 of extractives, and 2 per cent. of salts. The chief inorganic constituents are sodium chloride, calcium, magnesium, and ferric phosphates; calcium phos-

phate is said to be more abundant in pus coming from bone, but this is doubtful—there is merely a trace of potassium. The serum separated from the corpuscles contains about 90 per cent. of water. Of the solid constituents over 6 per cent. are proteids; not more than ·15 per cent. lecithin and other fats; and about ·8 per cent. salts, chiefly sodium chloride. It will be seen, therefore, that the lecithin and other fatty matters are chiefly contained in the corpuscles. Pus contains no fibrinogen, but fibrin-ferment has been shown to be present in it. The absence of fibrinogen in pus is most easily explained by supposing that the exudation from the vessels first coagulates in the zone in which the liquid pus has not yet formed, and then softens and breaks down. In addition to the above constituents, peptones and albumoses are found, formed under the influence of the micro-organisms which are constantly present in all acute suppurations. Leucin, tyrosin, and various less important substances are also often found in pus. Pus also frequently contains the specific virus of the disease with which its formation is connected, as in small-pox, glanders, tetanus, soft chancres, gonorrhœa, &c. The organisms specially connected with suppuration will be described later on. Many of the chemical substances found in pus have intense fever-producing (pyrogenic) powers if injected into the blood-stream.

Pus presenting the above characters is termed healthy or laudable pus (*pus bonum et laudabile* of the old writers), but various other terms are employed to indicate different appearances: thus, when tinged with blood it is called *sanious;* when thin and watery, *ichorous;* when containing cheesy-looking flakes, *curdy;* and when diluted with mucus, *muco-pus*. Besides these, pus presents other varieties; thus, for instance, when it is formed in the brain it is of a greenish tint, and when in the neighbourhood of the alimentary canal it has a peculiar, fetid odour.

Pus is a liquid which readily putrefies when exposed to the air or mixed with water at the temperature of the body, or even if septic organisms be introduced subcutaneously, as by an aspirator-needle or trochar. Thus we occasionally see that a collection of pus which, when tapped for the first time, is free from putrefaction, becomes offensive in a few days unless proper antiseptic precautions are taken during the operation. In some rare cases the pus, soaking a dressing, assumes a distinctly blue colour from the development in it of a special form of organism, the bacillus pyocyaneus. Blue pus is never found in a freshly opened abscess.

Microscopic Characters.—Pus consists of corpuscles floating in a clear fluid, the "liquor puris." In pus drawn from an acute abscess or from the surface of a healthy granulating sore, living cells, presenting amœboid movements if examined on a warm plate, and dead cells which have undergone degenerative changes, are met with, the latter being the true pus-cells, and by far the more abundant. The living cells are mono-nucleated and poly-nucleated leucocytes, and have already been described (*see* Migration of the Leucocytes). The typical "pus-cells" are the dead or degenerating leucocytes. They are rounded in form and slightly irregular in outline, and measure about $\frac{1}{3000}$-inch in diameter, and their protoplasm is coarsely granular, so that the nucleus is completely concealed. By treating with dilute acetic acid the granules are to a great extent dissolved, the protoplasm becomes swollen, and the nucleus comes clearly into view. It is then seen to be composed usually of three, sometimes of four or two parts, usually devoid of nucleoli

abundant that sometimes the mass is mistaken for a solid tumour. In bone, the enclosing tissue is composed of very dense osseous tissue. Pointing becomes impossible, and such an abscess may exist for an indefinite time. This form of abscess is met with in its most typical form in the mamma. One of the most acute forms of suppuration met with, leading very rapidly to the formation of large abscesses, is the disease known as Acute Necrosis of Bone. Here the pus forms under the periosteum, stripping it extensively from the bone, and finally perforates it, extending to the superficial tissues. The staphylococcus aureus or albus is constantly present as the cause of the disease. Now in this disease we not uncommonly get examples of abortion of the acute process. The severe constitutional and local symptoms subside, the process becomes chronic, and it may not be for some weeks that an abscess reaches the surface, at the bottom of which dead bone is found, surrounded by a large mass of newly-formed osseous tissue. It has not yet been proved that this is due to death of the micro-organism, either from the triumph of the living tissues over the invading micrococcus or from the development of some chemical substance fatal to it, but it is the probable cause of the mitigation of the symptoms. In one such case examined in University College Hospital no organisms could be cultivated on potatoes.

Abscess formation may also be more or less chronic owing to the feeble virulence of the organism causing the suppuration. The micrococcus pyogenes tenuis has been found only in abscesses running a subacute course.

The constitutional symptoms which have already been described (p. 249) correspond in severity to the acuteness of the process.

Situation, Size, &c.—Abscesses are met with in all *regions* of the body, but more especially where the areolar tissue is abundant and the lymphatic glands are numerous. They may occur at any *period of life*, from the earliest infancy to old age. I have opened a very large abscess in the axilla of a child about a fortnight old. Their *size* varies from that of a pin's point to that of a tumour containing a pint or more of pus.

The **Pressure effects** of an abscess are often important. By pressure on the nerves of a part it may give rise to severe pain referred to the nerve and its terminal branches. In deep-seated chronic abscesses this is often a most important element in diagnosis, and from want of attention to it many cases of lumbar and psoas abscess are treated as lumbago or sciatica till the abscess makes itself evident to the most superficial observer. Large veins are often pressed upon and obliterated, but this is very rarely the case with arteries. Abscesses rarely perforate large vessels, even when they are in close contact with them. This accident will be described at the end of the chapter.

Diagnosis.—The diagnosis of abscess, though usually easily made, at times requires close attention. The Surgeon believes that an acute abscess is about to form when, perhaps after a rigor and some increase of the inflammatory fever, he finds the local signs characteristic of the formation of pus; more especially a throbbing pain in the part, with softening of any induration that may have existed, and œdema of the areolar tissue covering it. His suspicion is turned into certainty, and he knows that an abscess has formed, when, after the occurrence of these symptoms, fluctuation can be felt. Fluctuation is the sensation felt by the Surgeon on placing both hands, or one or more fingers of each hand, as the case may be, with moderate firmness upon the part in which the fluid is situated, and then increasing the pressure with each hand alternately.

interest attaching to the subject is so great, that it may be well here briefly to describe the process. The reagents required are, a solution of methyl-violet (one of the aniline dyes), of the strength of half a grain to one ounce of distilled water, carefully filtered, and some pure Canada balsam, which has been heated to drive off its volatile oil. The method of observation is as follows: Spread the pus on a glass cover-slip in the thinnest possible layer, and dry it carefully over a spirit-lamp, taking care not to overheat it: dip a clean glass rod in the methyl-violet solution, and spread a thin film of the dye over the dried layer of pus; after from thirty to sixty seconds, wash the dye off carefully with a gentle stream of distilled water. A darkly-stained film should remain behind, which must be again dried over the spirit-lamp; then while the cover-slip is still warm, put on it a drop of the Canada balsam, rendered fluid by heat, and place it quickly on a glass slide which is also slightly warmed; squeeze it gently down, and when cold it is ready for examination. The micrococci are distinguished from other granules by their definite round form and uniform size, and by their arrangement in groups or chains. They, moreover, take the dye readily, while fatty and albuminoid granules remain uncoloured. Blood or urine may be examined by the same process.

There are, of course, many other methods of staining and preparing organisms, but the above will be found practically efficient for the ordinary pyogenic organisms.

The Chief Micro-organisms connected with Acute Suppuration.—In about 70 per cent. of all acute subcutaneous suppurations the organism present is a micrococcus (see p. 178) belonging to the group *Staphylococcus*, so named from the separate cells being heaped together in irregular masses resembling a bunch of grapes (Fig. 90). Staphylococci grow well at ordinary temperatures on nutrient gelatine, agar-agar and potatoes. When grown on gelatine they gradually liquefy it, and at the same time a slightly sour smell is given off. They generate no gas in their growth, and can either derive the oxygen from the air or from the tissues or fluids in which they may be growing in the body, that is to say, they can be aërobic or anaërobic, according to circumstances. Two chief varieties are commonly met with, *Staphylococcus pyogenes aureus* and *albus*. They are only distinguished by their growth on the various cultivating media, the aureus forming colonies of a golden-yellow colour, and the albus forming opaque white patches. The two forms are frequently found together in the same abscess, and are probably mere varieties of the same species. In rare cases another variety forming lemon-coloured colonies has been met with, and has received the name of *Staphylococcus pyogenes citreus.* The staphylococci give rise to localised suppurations, and show no tendency to diffuse themselves widely by the lymph spaces. On the other hand, they frequently penetrate the small vessels of the part in which they are growing, and

Fig. 90.—Pus from Acute Abscess, containing the Staphylococcus pyogenes.

may thus be disseminated through the body, giving rise to one form of pyæmia. Their presence has been demonstrated in pustules and boils upon the skin, in subcutaneous acute abscesses, in empyema, acute suppuration of joints, in acute necrosis of bone, and in suppurating wounds. They have been found in the air, especially of hospital wards, and in dirty water, and they are amongst the numerous organisms met with on the healthy skin.

In about 16 per cent. of all acute suppurations, another micrococcus, the *Streptococcus pyogenes*, is met with. It is so called from the fact that the separate cells tend to arrange themselves in chains usually of from four to ten or more links, but with them separate cells or two together are also found. This organism exactly resembles in every respect that found in cutaneous erysipelas—the *streptococcus erysipelatis*—and the question of their identity will be discussed in the chapter on Erysipelas. It grows on gelatine at ordinary temperatures, forming small punctiform colonies; but it does not liquefy the gelatine. It generates no gas in its growth, and is aërobic or anaërobic according to circumstances.

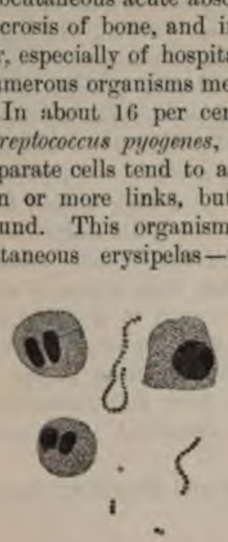

Fig. 91.—Pus containing the Streptococcus pyogenes.

The streptococcus is met with in diffuse suppurations, such as that occurring in phlegmonous erysipelas. It tends to spread widely by the lymph spaces, and has no tendency to invade the vessels, but it may enter the blood through the blood-stream, and is met with in some cases of pyæmia, especially those following labour or operations on the urinary organs. Chain-shaped micrococci are very commonly present in foul urine and in putrid fluids generally, but their identity with the streptococcus has not been proved. Streptococci and staphylococci are found together in about 5 per cent. of all suppurations.

The staphylococci and streptococci account for about 91 per cent. of all acute subcutaneous suppurations. The following are the most important of the other organisms that have been met with :—

The *Micrococcus cereus*, an organism without regular arrangement of its individual cells, forming, when cultivated on gelatine, a waxlike layer, has been described by Passet, but its pyogenic properties are doubtful.

The *Micrococcus pyogenes tenuis*, a very small organism without regular arrangement, first discovered by Rosenbach in a somewhat chronic abscess.

The *Micrococcus tetragenes*, very commonly found in human sputa, especially in cases of phthisis with cavities in the lung. It has also been met with in subcutaneous abscesses and gum-boils. It derives its name from its tendency to divide into four cells, which become surrounded by a gelatinous, transparent envelope.

The *Bacillus pyogenes fœtidus* is a very short rod-shaped organism, the length of which is about double its breadth. It can be cultivated on gelatine, which it does not liquefy, and produces foul-smelling gases in its growth. It has been found in foul-smelling abscesses near the rectum, in the brain, and in the gums.

The *Pneumo-bacillus of Friedländer*, an organism found in some cases of

acute lobar pneumonia, has also been met with in acute abscesses in the brain, joints and other parts usually in connection with pneumonia. It forms short rods, or sometimes chains surrounded by a clear capsule soluble in alkalies.

The above are the chief "pyogenic organisms" met with in surgical practice. The *Bacillus pyocyaneus*, or the organism of blue pus, is met with only on dressings, or in discharges from open wounds.

Many other organisms besides the above mentioned possess pyogenic properties, such as the micro-organism of gonorrhœa—the gonococcus—the bacillus of glanders, etc. These will be described with the diseases with which they are associated.

The proof of the Pyogenic properties of Micro-organisms.—The proof of the pyogenic properties of micro-organisms is derived, first, from the constant association of micro-organisms with suppuration; and secondly, from the experimental inoculation of the organisms, cultivated out of the body for several generations in order to get rid of any contamination from the fluid or solid constituents of the original pus. The results of these experiments have varied with the mode of inoculation, the quantity injected, and the animal experimented on.

Simple inoculation of the staphylococci on the skin in animals is usually without result. Subcutaneous injection of a cultivation made into an emulsion with a sterilised fluid produces abscesses in guinea-pigs, rabbits, dogs and mice, but in order to obtain this result it is necessary to inject a sufficient quantity. A small quantity, that is to say, a limited number of the organisms, can be destroyed by the living tissues, and consequently, though a limited inflammation and exudation may take place, an abscess is not formed. Intravenous injections, if in sufficient quantity, cause rapid death with symptoms similar to those of septic poisoning, and after death the presence of the organisms in the blood has been demonstrated. A smaller dose may be fatal in a few days, and on examining the animal after death, small vessels in many parts of the body, especially in the kidney and spleen, may be found to be plugged with masses of the micrococci round which small collections of pus may form. In some experiments, though not constantly, suppuration has been induced in subcutaneous injuries, such as fractures, by injecting the organisms into the blood-stream after the injury has been inflicted. In man, small subcutaneous abscesses have frequently been caused by the inoculation of the micro-organisms, and Garré excited acute inflammation with the formation of a large crop of boils on the skin of his arm by rubbing into it a gelatine cultivation of the staphylococcus aureus derived from a case of acute necrosis of bone. These results have clearly proved the pyogenic properties of the micro-organisms above mentioned.

The Mode of Action of the Micro-organisms in causing Suppuration.—The first step in the process of suppuration is that the pyogenic organism shall find its way to the part, which is most commonly previously damaged in some way. In an open wound the organisms may, as before stated, find their way in from the air, or from impure water, but it cannot be too strongly insisted upon that pyogenic organisms are in all probability constantly present on the surface of the patient's skin and on the Surgeon's hands, and that the thorough disinfection of these by soap and water, followed by an efficient chemical antiseptic, is the most important step in the prevention of suppuration. When suppuration takes place subcutaneously, the organisms find their way to the

part by the blood or lymph-stream. In the former case they may enter by th air passages or alimentary canal, or occasionally from another centre of sup puration, either directly or by the lymphatics. The distribution of th organisms by the lymphatics from a primary centre of suppuration is seen i the suppuration of the lymphatic glands so common in poisoned wounds, so chancres, &c.

The organism having then effected a lodgment damages the surroundin tissues, probably in all cases chiefly by the chemical products formed in it growth, and thus sets up the process of inflammation, which must be regarde as the defensive reaction of the part against the invading pathogenic fungu The chemical irritant acting upon the tissues, as described in the chapter o Inflammation (p. 174), suspends their vitality, or, in other words, damag them in proportion to its intensity. In order that suppuration may tak place, this damage must be of a certain degree, and persist for a sufficien time. The first effect is to cause the ordinary signs of dilatation of the vessel with retarded flow and exudation with migration of leucocytes, which mov towards the spot invaded by the micro-organisms. This movement towar the organisms is explained most commonly by the theory that the products their growth exert an attractive influence on the amœboid cells—positiv chemiotaxis (p. 161). If the inflammation quickly subsides and a return health takes place, it is believed to be due to destruction of the invadin organisms. How this is effected is a matter which at the present time giving rise to much discussion, and cannot be regarded as by any mea settled. That the organisms are frequently found in the substance of th migrated cells is undoubted. They are found both in an active state an degenerating as indicated by the readiness or difficulty with which th stain. That sometimes they appear to multiply in the phagocytic cell, an causing its death, is also certain. According to Metchnikoff and his follower the whole process of migration is conservative, and the migrated cells actin as phagocytes seize upon the invading micro-organisms, take them into the substance and destroy them by intracellular digestion. In the struggle, ma of the defending cells may perish from the action of the chemical products the organisms, and from overcrowding and want of nutrition, and these for the dead pus-cells. This view, which looks upon the phagocytes as the chi if not the only protectors of the body against the invasion of pathogenic fung is opposed by many pathologists, of whom Buchner may be considered th chief. They maintain that the phagocytes are engaged in clearing the tissu of necrotic elements which have perished from the action of the chemical pr ducts of the invading organisms, and that when the organisms are found the migrated cells, they have either been taken up by the phagocytes after th have perished from other causes, or are actively invading the migrated cell which are themselves perishing. They maintain that, when an invadin organism perishes, its death is brought about by the chemical action of th fluids of the part. They maintain that the normal blood serum possess bactericidal properties towards certain organisms, and that chemical substanc may be formed, possibly from the breaking up of some of the migrated co puscles, which are even more potent in killing the organisms or inhibitin growth. Again, it is not impossible that the organisms themselves ma growth give rise to chemical products which arrest their furth ent. Whatever may be the ultimate solution of the question, th

fact remains that, under the influence of the pyogenic fungi, leucocytes crowd the invaded area, and the organisms are found amongst and within the migrated cells. Many organisms which are intensely pathogenic are not pyogenic. For example, the bacillus anthracis, the virus of anthrax or splenic fever, when inoculated on the human subject, invades the tissues, causing gangrene in the infected area, but no pus is formed. In this case the intensity of the irritant is such that all movements of the leucocytes are arrested. In many of the experiments that have been carried out with pathogenic organisms capable of exciting local suppuration, or, under favourable circumstances, of invading the whole body, it has been found that the danger of general infection diminished with the activity of the local process. Thus, Ruffer and Walker found that, on injecting a moderate dose of a cultivation of the bacillus pyocyaneus beneath the skin of a rabbit, abundant migration took place, and the organisms were destroyed locally without any general infection, but if the leucocytes were paralysed by the injection of a sufficient dose of chloral at a distant part of the body, no migration took place, and the animal soon died with the blood teeming with bacilli. In the same way, if a cultivation of a pyogenic organism be mixed with a weak solution of carbolic acid or corrosive sublimate, which has a negative chemiotactic action, that is to say, repels the migrating cells, while at the same time it is not strong enough to kill the organism, no pus will be formed, though there may be some serous exudation, and in the absence of the local defensive reaction, general infection takes place.

Having then got abundant migration and crowds of cells invading the original tissues, taking their place and consuming them where the damage is most intense, the next step is the liquefaction of the intercellular substance and the formation of fluid pus. Here again we have a doubtful point to consider. Does the exudation coagulate as already described in acute inflammation (p. 162), and then soften, or is its coagulation prevented by the presence of some chemical substance, probably peptones, developed under the influence of the micro-organism? It has before been mentioned that pus from an acute circumscribed abscess contains no fibrinogen; on the other hand, peptones are almost constantly present, a fact which may be used to support both theories. Most probably both processes may occur according to circumstances and the nature of the organism causing the suppuration. In the circumscribed acute abscess the lymph spaces round are in all probability plugged with coagulated "lymph"—at least the microscopic appearances suggest this view—and this is subsequently softened by the action of the micro-organism as the suppuration advances. In the diffuse suppurations, such as in phlegmonous erysipelas, it is probable that the exudation becomes purulent without ever having coagulated. In croupous pneumonia there can be no doubt that the exudation which is coagulated at first becomes softened and purulent later on.

Can Suppuration take place in the absence of Micro-organisms?—It is now generally recognised as a fact that practically all pus with which the Surgeon has to deal is directly caused by the presence of micro-organisms, but experiments have clearly proved that suppuration is possible without their living presence. These experiments have been most frequently carried out by the introduction of glass tubes or capsules containing the substance to be tested into the subcutaneous tissues by means of an open wound under the strictest antiseptic precautions. When the wound has healed by the first intention

and remained sound for some time the capsule is ruptured by pinching it through the skin and the animal killed a day or two after, and the part carefully examined. In many of these experiments there was the obvious fallacy that the substance used was so small in amount and so diffusible that its effect must have been so transient as hardly to be likely to cause suppuration. With other substances, especially sterilised cotton oil, turpentine and metallic mercury, pus was frequently produced in which the absence of organisms was proved both by microscopic examination and by cultivation. Aseptic suppuration has also been induced by the injection of sterilized cultivations of various pyogenic organisms, of putrid fluids, and of some ptomaines derived from them, especially cadaverin and putrescin. Buchner believes that the pyogenic material is often contained in the organisms themselves, and that this may be the case is suggested by the fact that Koch found that the injection of cultures of the tubercle bacillus in which the organism had been destroyed by heat gave rise to suppuration if injected subcutaneously, and that it was necessary therefore to separate the dead organisms in the preparation of the so-called tuberculin.

There is, however, one fundamental difference between the suppuration caused by chemical substances and those in which organisms are present. The former are not progressive, as the pyogenic virus does not increase in quantity; the latter are progressive.

Mechanical irritants, such as tension and friction of surfaces against each other, were formerly credited with the power of causing aseptic suppuration, and many cases of the formation of pus in an ill-drained wound were explained in this way, but as our methods of detecting micro-organisms have been perfected it has been proved that in such conditions micro-organisms are always present. That when suppuration is established these sources of irritation increase the formation of pus is, however, a fact which few practical Surgeons can doubt. In the extreme tension caused by the subcutaneous rupture of an aneurism or a large vessel inflammation and suppuration not uncommonly occur beneath the unbroken skin, but no case of examination of the pus for micro-organisms seems as yet to have been recorded.

The presence of a foreign body in the tissues was at one time considered a sufficient cause of suppuration, but experience in the use of silk ligatures has proved that this is not the case, and that the presence of micro-organisms is the true cause of suppuration in such cases.

The influence of chemical substances in the formation of pus is very evident in granulating wounds, as, for instance, a healthy granulating sore of the leg. If the patient be put to bed with the leg elevated, to avoid intravascular tension, and the raw surface be rendered perfectly aseptic, and then covered by a non-irritating substance, and protected from mechanical violence and cold by an application which at the same time absorbs the discharge and prevents its putrefaction, every source of irritation being thus removed, we may succeed in completely preventing any formation of pus. The discharge, such as it is, will be composed solely of serous fluid, which necessarily leaks from the surface of the granulations, as they are uncovered by any impermeable epithelium. Having got the sore into this state, if some mild irritant be now applied, as for example, lint soaked in a concentrated solution of boric acid, the discharge will become turbid, the superficial cells perishing and being cast off under the influence of the irritant, while at the same time

migration takes place from the vessels beneath; if a stronger irritant be applied, as, for example, carbolic acid water (1 in 40) or sulphate of zinc (two grains to one ounce of water), or a 1 per cent. emulsion of creolin, the discharge will become thick pus. Suppose now that a still stronger irritant be applied, as a solution of carbolic acid (1 in 20), or the discharge be allowed to become putrid, the discharge of pus continues and the granulations become soft and swollen from exudation of blood-plasma into their substance. If a stronger irritant still be applied, as a spirituous solution of carbolic acid, the superficial cells perish, forming a slough, and the migration of leucocytes towards the surface is arrested, and all discharge of pus consequently ceases.

Can simple Septic Organisms—Saprophytes—give rise to Suppuration?—It has already been stated that various ptomaines, cadaverin, putrescin, &c., have been proved to be capable of causing the formation of pus without the presence of living organisms. It seems almost certain, therefore, that the products of putrefaction are capable of causing suppuration, and this view is confirmed by clinical experience. If an abscess be opened, and putrefaction of the discharges be prevented, the discharge of pus ceases almost immediately, but if putrefaction take place suppuration continues, the discharge being very abundant. It seems impossible to doubt that the chemical products of putrefaction here act as pyogenic agents.

The Accessory Causes of Suppuration.—That the formation of pus is promoted and increased by anything that irritates the tissues seems beyond question. Every practical Surgeon knows that in a suppurating joint movement increases the discharge. Tension, though probably not in itself capable of causing suppuration, is, by the damaging influence it exerts on the surrounding tissues, one of the chief causes of the persistence of suppuration in an unopened abscess. It probably diminishes the power of resistance of the tissues to the invasion of the pyogenic organisms. In spreading suppurations such as phlegmonous inflammations, free incisions, relieving tension, frequently arrest the progress of the disease at once. The organisms are still present, but the resistance of the tissues is increased by the relief of tension.

Any constitutional condition which weakens the patient also predisposes to suppuration.

The **Duration** of suppuration necessarily varies greatly. In wounds which fail to heal by primary union, pus usually appears about the third day, but it may be delayed beyond that time. When once established it continues as long as the cause persists; thus an ulcer of the leg or a sinus leading to diseased bone, or a chronically inflamed mucous membrane, may discharge pus for many years.

SYMPTOMS OF SUPPURATION.—These are local and constitutional, and necessarily differ according as the process is deep or superficial, acute or chronic.

The *Local Symptoms* of subcutaneous suppuration giving rise to the formation of an abscess will be described further on (p. 252). In chronic superficial suppuration from a granulating sore, the discharge of pus is practically the only symptom.

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CHAPTER VI.

ULCERATION.

Ulceration is a progressive destruction of the tissues, in which the solid parts seem to melt away into a liquid discharge without the separation of visible portions of dead tissue. The meaning of the term will be made more clear by a few examples. If a piece of skin be killed, as by a caustic, or by mechanical violence, there is at first no solution of continuity, the dead tissue is everywhere continuous with the living; but within a few hours the phenomena of inflammation manifest themselves in the surrounding living tissues, thus imperfectly marking out the limits of the part that is killed. By about the second or third day the line between the dead and living becomes more clearly defined, the cuticle at the margin of the living part becomes loose, and is raised by fluid beneath it, and at last comes away, exposing a narrow raw surface discharging pus; the living tissues which lie in immediate contact with the dead then seem gradually to melt away into the purulent discharge till a complete solution of continuity is established, the dead part, or "slough," being loosened and finally cast off. This process, by which a slough is separated from the parts beneath, takes place entirely at the expense of the living tissues; it is spoken of as ulceration, and the sore left is called a **simple ulcer.**

The effect produced by the inoculation of the poison of a soft chancre forms another excellent example of ulceration. Within twenty-four hours of the inoculation a small inflamed spot appears, with redness, swelling and itching: by the third day the cuticle is raised by a drop of pus: when the thin epidermis is removed a small red sore is seen, from which pus exudes: this slowly extends, the discharge being purulent, and at no time do any visible portions of dead tissue come away with it; the surrounding tissues show the ordinary signs of inflammation. Such a sore is a **specific ulcer**, the irritant which causes it being a specific poison.

A third form of ulceration, differing essentially from the two preceding, is seen in the later stages of the growth of malignant tumours. Thus an epithelioma commences as a small hard growth, which infiltrates the surrounding tissues. By the pressure of the growth which forces its way into the interstices of the structures which it is invading, the original tissues become absorbed, and the cancer-tissue comes to occupy their place. When the owth reaches a certain size its central parts degenerate, soften and break wn, and a loss of substance takes place. As the disease progresses the urrounding tissue becomes invaded and destroyed by the cancerous growth, which in its turn breaks down and melts away superficially. Thus the most extensive destruction may take place. This process is described as ulceration, although here there may be no true inflammation, and the resulting sore is **malignant ulcer.**

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migration takes place from the vessels beneath; if a stronger irritant be applied, as, for example, carbolic acid water (1 in 40) or sulphate of zinc (two grains to one ounce of water), or a 1 per cent. emulsion of creolin, the discharge will become thick pus. Suppose now that a still stronger irritant be applied, as a solution of carbolic acid (1 in 20), or the discharge be allowed to become putrid, the discharge of pus continues and the granulations become soft and swollen from exudation of blood-plasma into their substance. If a stronger irritant still be applied, as a spirituous solution of carbolic acid, the superficial cells perish, forming a slough, and the migration of leucocytes towards the surface is arrested, and all discharge of pus consequently ceases.

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largely due to the entrance into the blood-stream of the various chemical products of the growth of the micro-organisms which are causing the formation of pus. In acute inflammations the occurrence of suppuration is usually marked by an increase of fever, sometimes accompanied by a rigor, but far more commonly only by slight chills. The temperature rises considerably above normal, reaching 103° F. or 104° F. The evening temperature is as a rule about one degree above that of the morning. This high temperature remains unchanged in a case of simple acute abscess till the pus is discharged either artificially or naturally. It then falls rapidly, and if the cavity be completely drained, soon reaches the normal degree. When the abscesses are merely a part of the general process of blood-poisoning, repeated rigors occur, and although opening the abscesses may relieve the patient, it seldoms brings the temperature to a normal point. When suppuration occurs in a recent wound or compound fracture, the fever which precedes it is due in the majority of cases to absorption of septic matter from the raw surfaces; consequently, as granulations spring up and cover them and present an efficient barrier to the entrance of the products of decomposition into the circulation, the fever falls, and this usually occurs coincidently with the full establishment of a thick healthy purulent discharge.

In chronic suppuration from a surface there is no elevation of temperature, and the same may be the case in a well-drained cavity, but some fever is sure to appear in the latter case should any accumulation be allowed to take place.

In chronic abscesses, especially in those due to tubercle, the fever is slight, but almost invariably careful observation with the thermometer will show some slight elevation of temperature. It may not be more than a degree above the normal standard, and that in the evening only, but when present for any length of time it is an important aid in diagnosis.

In chronic suppuration from cavities the condition known as *hectic* is often established, or *albumenoid degeneration* of the liver, spleen, and kidneys may set in.

Hectic is a fever of long duration, always accompanied by progressive emaciation and loss of power. The pulse, which is quick, small and compressible, rises from ten to twenty beats above its normal standard; the tongue becomes red at the edges and tip; the cheeks are often flushed, and the eyes glistening, with dilated pupils; all these symptoms have a tendency to exacerbation after meals and towards evening. Profuse sweating and copious diarrhœa are common, and these discharges often alternate with one another, melting the patient away, as it were, and hence are termed *colliquative*. The debility gradually increasing, the patient rapidly wastes, and at last dies from sheer exhaustion, the conjoined result of fever, malnutrition, and wasting discharges.

The nature of hectic fever is a subject on which there has been much difference of opinion. It does not occur unless there is a chronic discharge of pus from the system, and it was formerly supposed to be due in some way to the exhausting effects of the loss of albumen and the other constituents of pus. There can be no doubt, however, that in most, if not in all, surgical cases hectic is in reality chronic poisoning from the absorption of the chemical products of putrefaction, or some other fermentative change going on in the pus. No hectic occurs so long as an abscess, however large, continues

fascia, as in the axilla, or beneath the fascia lata, may extend through the areolar planes of the part, burrowing widely in various directions. In the medulla or cancellous tissue of bone the pus may be imprisoned by the surrounding dense tissue and be unable to reach the surface.

It is possible that very small collections of pus may become absorbed, and thus the abscess may disappear.

After an abscess has burst or has been evacuated, its walls contract and become corrugated, and the cavity is gradually closed by a process of repair identical with the healing of a wound by granulation (*see* Process of Repair). In some cases, however, the cavity does not completely close, but contracts into a narrow canal forming a sinus or fistula (p. 267).

Acute abscesses arising in various parts of the body, as the viscera, joints or subcutaneous tissue, in consequence of the dissemination through the body of particles of infective material derived from a primary centre of inflammation, and carried by the blood-stream, are termed *Metastatic*, and form the prominent feature of pyæmia, with which they will be described.

In the neighbourhood of the alimentary canal abscesses are occasionally met with containing gas as well as pus. These are termed *Tympanitic* or *Emphysematous*. In some cases this is due to a definite communication with the intestines, but in others this is not so evident. These collections are often resonant on percussion, and sometimes gurgling is very distinct in them.

In all acute abscesses the febrile disturbance described on p. 250 is very marked.

Chronic Abscesses are often called also cold or lymphatic, or, from the tendency of some forms gradually to advance in a downward direction, gravitation abscesses. There is no sharp line to be drawn between acute and chronic abscesses. In some cases the process of suppuration, which may be acute at first, may gradually become chronic, and in others a chronic process may at the end become more or less acute. The term *subacute* is sometimes applied to cases between the two extremes.

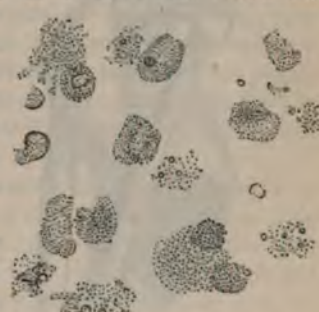

Fig. 92.—Pus from Chronic Abscess.

Chronic abscesses, like the acute, probably arise invariably as a result of the invasion of the tissues by a pathogenic organism, but in the most common form of chronic abscess the ordinary pyogenic fungi are not concerned in the process. The great majority of chronic abscesses are of tuberculous origin, and the most typical form is that so commonly met with in connection with diseases of joints and bones, especially the bodies of the vertebræ. The pathological changes met with in tubercle will be more fully described in the chapter on that disease. It will be sufficient here to state that the invasion of a part by the tubercle bacillus sets up a chronic inflammatory process, leading to the destruction of the original tissues and the accumulation of a mass of new cells surrounding the invading organisms, and round this again is frequently a zone in which, as a result of the irritation, new connective tissue is formed enclosing the cellular mass. In all tuberculous processes the cells enclosing the bacilli tend to undergo fatty degeneration, and thus a

turbid with cells. The whole process thus merges into gangrene. No sharp line can be drawn between spreading gangrenous inflammation and ulceration, and we call the intermediate conditions by such names as sloughing, gangrenous or phagedænic ulceration.

2. In pa.ts which have long suffered from chronic inflammation, slight mechanical and chemical causes give rise to ulceration.

3. Ulceration sometimes commences in the crypts, or follicles, which open on mucous surfaces, as a consequence of catarrhal inflammation, with accumulation of secretion within their cavities. It leads to the formation of circular depressed ulcers.

4. In some general diseases, accompanied by the formation of vesicles or pustules on the cutaneous surface, ulcers may be left when they burst, as in small-pox, pemphigus, syphilitic rupia, and occasionally in chicken-pox.

5. Any injurious influence, whether chemical or mechanical, which causes the death of a part, necessitates the occurrence of ulceration for the separation of the dead tissue, and the sore so left is an ulcer. Long-continued pressure is a common cause.

6. In some specific cases, as before stated, ulceration is preceded by the formation of a morbid growth, as a syphilitic gumma, tubercle, or a malignant tumour.

Situation.—Ulcers may be situated upon any part of the cutaneous surface as the result of loss of substance from wound or other injury. Syphilitic or strumous ulcers may appear on almost any part either of the skin or the mucous membranes, but they most frequently occur in particular situations, as on the penis, lips, tongue, or rectum. Of all forms, however, perhaps the most common with which we have to deal, is the simple ulcer of the leg, so frequently seen in hospital out-patient rooms. The lower half of the leg is the usual seat of these simple ulcers, the skin of that part being much exposed to mechanical violence, and very prone to congestion from position, from varicose veins, and from its great distance from the centre of circulation. In advanced life, moreover, degenerative changes in the arteries of the leg obstructing the flow of blood are very common. Ulcers that form here are slow in healing, and very likely to recur, because the conditions that led to their formation may still exist: also there is often but a very thin layer of subcutaneous fat between the skin and the tibia, and, consequently, there is a great tendency for the under surface of the scar to adhere to the bone.

General Treatment of Ulceration.—In the **Local Treatment** of ulceration, the Surgeon must be guided by the special conditions presented by the ulcer, as presently described; but there are some points which demand attention in all cases. 1. Every source of irritation which could cause inflammation, or maintain it if present, must be carefully removed; for while inflammation is present no proper reparative process can go on. Thus, if the ulceration be due to the presence of a specific poison, as in the case of a soft chancre, this must be destroyed by antiseptic or caustic applications. In simple sores the surface must be preserved from friction, the part must be kept at rest, and the decomposition of the discharges must be prevented by proper applications. 2. The circulation must be maintained in a normal state, both congestion and local anæmia being guarded against; as, without a normal supply and a sufficiently rapid change of blood, the growth of the reparative tissue cannot take place. Constriction must therefore be avoided, and the

fluid they contain is usually thin, flaky and curdy, though in some cases the pus is healthy in appearance. Sometimes they contain masses of a soft yellowish substance, apparently formed of coagulated fibrin entangling the fatty remains of degenerated cells, but more commonly the shreds and flakes are of small size. No micrococci or bacteria are found in the pus of a chronic abscess of this kind, nor can tubercle bacilli be recognised as a rule by microscopic examination. This is probably due to the fact that the bacilli in the contents of the abscess have probably broken up, leaving only their spores, for inoculation experiments on animals show that the virus of tubercle is present in the fluid contents of the abscess. The microscopic examination of the sac usually demonstrates the presence of tubercle. Occasionally, even after an abscess of this kind has reached a considerable size, its fluid contents may be absorbed and the abscess undergo a spontaneous cure, its site being indicated, if the opportunity arises of examining it, by some dry cheesy matter enclosed in a dense scarlike mass of fibrous tissue.

The above is a description of the most typical form of the chronic tuberculous abscess, but intermediate forms are met with between it and an acute abscess. In joints, abscesses due to tubercle, especially if rest of the affected part be not ensured, not unfrequently contain thick pus with abundant pus-cells, and the wall is formed of a fungating pulpy mass of granulation tissue. In these it sometimes happens that there is a double infection of the tubercle bacillus and one of the common forms of pyogenic micro-organisms. Again, it sometimes happens that a chronic abscess which has scarcely advanced for months may rapidly increase in size, and be found, on being opened, to contain thick creamy pus. This, also, is probably due in some cases to infection of the cavity with the acute pyogenic organisms.

Chronic abscesses, most frequently due to tubercle, are also met with very commonly in the lymphatic glands, and sometimes in bursæ or in the subcutaneous tissue. As they slowly approach the surface, the skin becomes purple and congested, and finally gives way at one point, allowing the curdy fluid to escape, leaving a cavity beneath the undermined skin which is very difficult to cure.

The so-called *Lymphatic* or *Congestive* abscesses, which are met with in cachectic individuals, arising often without very evident cause in the iliac fossa, axilla and other places, are probably in most cases tuberculous, arising in connection with some small patch of disease in a bone or elsewhere, which has given rise to no pain or other symptom to draw attention to it, so that the fluctuating swelling may be the first symptom noticed.

In *Actinomycosis*, that is to say, the infection of the tissues by a peculiar ray-shaped fungus is another occasional cause of chronic suppuration. (*See* Actinomycosis.) The softening of a *syphilitic gumma* may also form a collection of fluid of the nature of a chronic abscess. (*See* Syphilis.)

Another very important form of chronic abscess is not uncommonly met with in practice. It arises from an arrest or abortion of the acute process. It is probable that this is caused by the death of the micro-organism after the formation of a definite abscess cavity. The acuteness of the process then subsides, owing to the cessation of the formation of irritating products of the organisms. The presence of the fluid causes a very mild irritation (or stimulation) of the surrounding tissues, leading to an overgrowth of the connective tissue. The fluid thus becomes enclosed in a dense wall of fibrous tissue, so

abundant that sometimes the mass is mistaken for a solid tumour. In bone, the enclosing tissue is composed of very dense osseous tissue. Pointing becomes impossible, and such an abscess may exist for an indefinite time. This form of abscess is met with in its most typical form in the mamma. One of the most acute forms of suppuration met with, leading very rapidly to the formation of large abscesses, is the disease known as Acute Necrosis of Bone. Here the pus forms under the periosteum, stripping it extensively from the bone, and finally perforates it, extending to the superficial tissues. The staphylococcus aureus or albus is constantly present as the cause of the disease. Now in this disease we not uncommonly get examples of abortion of the acute process. The severe constitutional and local symptoms subside, the process becomes chronic, and it may not be for some weeks that an abscess reaches the surface, at the bottom of which dead bone is found, surrounded by a large mass of newly-formed osseous tissue. It has not yet been proved that this is due to death of the micro-organism, either from the triumph of the living tissues over the invading micrococcus or from the development of some chemical substance fatal to it, but it is the probable cause of the mitigation of the symptoms. In one such case examined in University College Hospital no organisms could be cultivated on potatoes.

Abscess formation may also be more or less chronic owing to the feeble virulence of the organism causing the suppuration. The micrococcus pyogenes tenuis has been found only in abscesses running a subacute course.

The constitutional symptoms which have already been described (p. 249) correspond in severity to the acuteness of the process.

Situation, Size, &c.—Abscesses are met with in all *regions* of the body, but more especially where the areolar tissue is abundant and the lymphatic glands are numerous. They may occur at any *period of life*, from the earliest infancy to old age. I have opened a very large abscess in the axilla of a child about a fortnight old. Their *size* varies from that of a pin's point to that of a tumour containing a pint or more of pus.

The **Pressure effects** of an abscess are often important. By pressure on the nerves of a part it may give rise to severe pain referred to the nerve and its terminal branches. In deep-seated chronic abscesses this is often a most important element in diagnosis, and from want of attention to it many cases of lumbar and psoas abscess are treated as lumbago or sciatica till the abscess makes itself evident to the most superficial observer. Large veins are often pressed upon and obliterated, but this is very rarely the case with arteries. Abscesses rarely perforate large vessels, even when they are in close contact with them. This accident will be described at the end of the chapter.

Diagnosis.—The diagnosis of abscess, though usually easily made, at times requires close attention. The Surgeon believes that an acute abscess is about to form when, perhaps after a rigor and some increase of the inflammatory fever, he finds the local signs characteristic of the formation of pus; more especially a throbbing pain in the part, with softening of any induration that may have existed, and œdema of the areolar tissue covering it. His suspicion is turned into certainty, and he knows that an abscess has formed, when, after the occur-[illegible] of these symptoms, fluctuation can be felt. Fluctuation is the sensation [illegible] Surgeon on placing both hands, or one or more fingers of each [illegible] case may be, with moderate firmness upon the part in which the [illegible]ated, and then increasing the pressure with each hand alternately.

On so doing, if fluid be present a wave will be felt to pass from under the hand which is pressing more strongly, raising that which is applied less firmly. In feeling for fluctuation the Surgeon should always place as large a surface of each hand as possible over the supposed fluid. The fingers should be curved so as to adapt themselves evenly to the part, and the pressure should be gentle and steady. If merely the tips of two fingers be poked into an inflamed part it gives pain to the patient, causing him involuntarily to wince and contract the muscles in the neighbourhood, thus obscuring all definite sensations of fluctuation. In large collections of fluid, as in ascites, one hand may be placed on one side and the opposite side struck a smart blow with the tip of one finger of the other hand, when a sharp impulse will be felt distinctly communicated through the fluid. This method of feeling fluctuation is, however, scarcely ever practicable in the case of an abscess.

Fluctuation may readily be confounded with the undulatory sensation communicated by some tissues from mere inflammatory infiltration into them. This, indeed, is a difference of degree rather than of kind; as pus would make its appearance in the course of a few hours, if the tumour were left to itself. Even without this, certain parts give very deceptive sensations from their natural laxity, as is sometimes the case in the areolar tissue of the nates and thigh. A still more perfect sense of fluctuation is given by a muscle when the hands are applied transversely to its fibres; and, consequently, in all cases it is a rule to feel for fluctuation with the hands applied first along and afterwards across the line of any muscle that may be situated beneath or over the suspected collection of fluid. Many soft solid growths give a sense of fluctuation almost as distinctly as fluid, deceiving even the most experienced. In the case of an encapsuled tumour the distinction can readily be made by pressing on its edge with the tip of one finger. If it is a chronic abscess or cyst, unless it be very tense, the finger goes through the swelling without anything being felt to move; in the case of a tumour the solid edge is felt to roll away. In some rare cases, even when fluid is present, fluctuation may be wanting, as the tension may be too great to allow of a wave being produced in the contents of the cavity. The occurrence of fluctuation alone, however, is not of itself sufficient to determine more than that a fluid exists in the part. The question necessarily arises, is this fluid pus? In the majority of abscesses, the history of the case, the character of the pain, the elevation of the temperature, the previous existence and the continuance of symptoms of inflammation, enable the Surgeon to answer in the affirmative. But if, as in chronic or cold abscesses, there be only obscure evidence of inflammation having existed, and if the swelling be of long standing, the fluctuation being perhaps deeply seated and indistinct, the safer plan will be for the Surgeon to introduce an exploring needle, and to see what the true nature of the fluid is; by this simple means many embarrassing mistakes in diagnosis may be avoided.

The tumours with which abscesses may more easily be confounded, are those *soft solid growths* in which there is a high degree of elasticity, giving rise to a species of undulation, as in some soft sarcomata. *Fluid tumours* of various kinds, such as cysts and enlarged bursæ, may also be confounded with abscesses. In these cases the previous symptoms, the temperature, the situation, and the general appearance and feel of the tumour, will usually enable the Surgeon to make a diagnosis; but should any doubt exist, the

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... in cases in which it is desirable to withdraw so...
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... an exhausting syringe from which lead two short nozzles...
... To one of these is fitted an india-rubber tube, at th...
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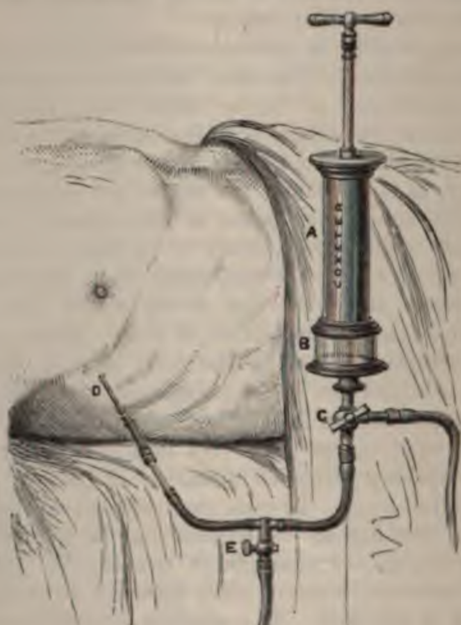

Fig. 94.—Aspirator, convertible into a Siphon.

A. Brass syringe. B. Glass at lower end. C. Stop cock, putting the syringe into connection with the discharge pipe or the needle. D. Needle. E. Small cock, opening into a side tube, to be ... a siphon if required.

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Fig. 94 represents Coxeter's aspirator, which can be converted, if necessary, into a siphon. One stop-cock C, as represented in the drawing, closes both tubes. The piston A being withdrawn, and a vacuum so produced, the cock C is turned on so that it is parallel to the syringe, and the vacuum is thus put in connection with the needle D. While doing this, the small cock at E must be closed. If it be determined to use the apparatus as a siphon, the cock E must be opened, and the handle of the piston forced down so as to fill the long tube passing downwards from E with the fluid already drawn from the cavity. The cock C now being turned off, the fluid will continue to flow.

The diagnosis of an abscess having pulsation communicated to it by a subjacent artery from an *aneurism* will be discussed when we come to speak of that disease.

Prognosis.—Abscesses vary greatly in danger according to their nature, situation and cause. Pyæmic abscesses are necessarily very fatal, as they commonly occur in the viscera, and are a part of a most dangerous general infective process. An acute abscess is not in itself a serious disease when it can be opened and properly treated; it becomes serious when situated in an important organ as the brain, lung, or kidney; when so situated as to be likely to burst into one of the large serous cavities, or to implicate a joint; or it may become serious by giving rise to general infection. Chronic abscesses are frequently very serious affections, as they are often associated with progressive tuberculous disease of bones or joints. Their size is another source of danger, especially if the large cavity is allowed to become septic after opening. Death from septicæmia is then very common. The age and state of general health are also important. In old or very feeble persons the pain, fever and discharge, even from a comparatively small abscess, may prove fatal.

TREATMENT.—The treatment of suppuration presents three points requiring attention. The first object should be to prevent the formation of matter; the next to take steps for its evacuation when formed; and the last to endeavour to close the cavity that results. The treatment necessary to prevent suppuration in open wounds, or, in other words, to obtain union by first intention, will be fully described in Chapter IX.

In cases in which there is no open wound, the preventive treatment of acute suppuration is nothing more than the preventive treatment of inflammation already described (p. 204). In chronic inflammations threatening to end in suppuration, the constitutional treatment described on p. 229 is of the greatest importance in preventing its occurrence.

Time of Opening.—In an **Acute Abscess,** the matter should in all cases be let out as soon as its presence is recognised. When this is done, the patient at once experiences great relief; the fever and general irritation subside materially, the free incision not only letting out the pus, but removing tension and relieving pain. The rule of opening an acute abscess early is especially imperative when the pus is formed in the sheaths of the tendons and under fibrous expansions where there is much tension; also when it is situated deeply in the areolar planes of a limb, under the larger muscles, where it has a tendency to diffuse itself extensively. In those cases, likewise, in which pus is lodged in close proximity to a joint or under the periosteum, it

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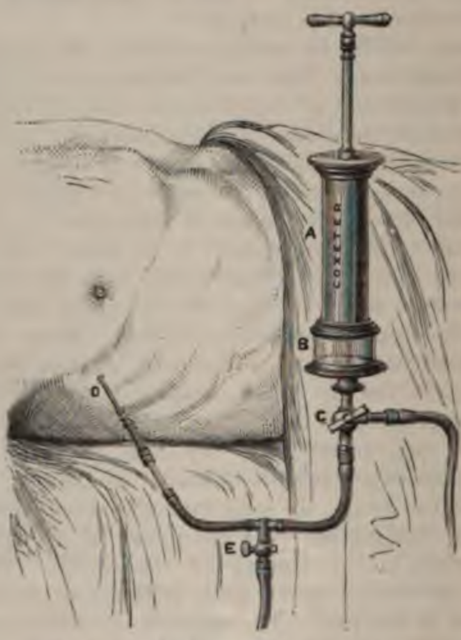

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Under this plan of treatment the edges will subside, the surface of the sore will become florid, and granulations yielding abundant discharge will speedily spring up. Much of the success of this plan of treatment will depend upon the close attention that is paid to it. If the skin be irritable, resin plaster should not be used, but merely the soap or lead; and the plasters should be changed at least every forty-eight hours. If the discharge be very abundant, small holes should be cut in the strips to allow it to escape. When by this mode of treatment the edges of the sore have been brought down, and the granulations sufficiently stimulated, an astringent lotion with bandaging may advantageously be substituted for the plasters. The great difficulty in carrying out this treatment in hospital out-patient practice, in which the patient is usually seen only twice a week, arises from the foul state into which the sore gets in the intervals of strapping; it is therefore very important to employ if possible some antiseptic mode of dressing. In order to do this, the first necessary step is to disinfect the sore, which when first seen is usually very foul. This is by no means so easy as might be supposed. It can be done by the free application of chloride of zinc (gr. xx. to ℥j.), but this is very painful; another plan is the application of a hot boric acid dressing as before described, changed every four hours, for two days, and this is very efficient if the patient can only be trusted to do it. Perhaps the best plan is to powder the whole surface of the sore with iodoform in crystals; this is efficient, and as a rule painless. When the sore is quite clean it may be dressed as follows: apply a small sprinkling of powdered iodoform, over this place a piece of protective green oiled silk, then strap the limb, heating the strips of plaster by dipping them in a hot solution of carbolic acid (1 in 40), then apply a carbolic gauze bandage from the foot to the knee to protect the skin, over this put a thick pad of carded oakum to absorb the discharge, and over all place a common calico bandage. The improvement that results from this treatment is often most surprising.

Another mode of applying pressure has been introduced by Martin, of New York. It consists simply in the application of a bandage made of pure india-rubber, free from sulphur. The bandage is applied directly to the sore, no dressing being used when it is on. It is worn only by day; and at night some simple dressing, *free from grease*, may be used. The bandage is thus applied: Before rising from bed in the morning, the patient rolls the bandage round the leg, taking care not to pull it in so doing. It must only just lie smoothly on the limb, for any traction might seriously impede the circulation. The patient now rises from bed, and the slight increase in the size of the limb from gravitation of blood into it tightens the bandage sufficiently to make it keep its position. At night the bandage is removed, sponged with warm water, and hung up to dry. The leg must also be carefully washed, and the sore may be dressed with some simple lotion. The only inconvenience of the treatment is, that from the obstruction to the escape of the perspiration, eczema is frequently set up. This is best treated with some oxide of zinc powder, and usually, after a short time, the leg seems to become accustomed to the presence of the bandage, and no further trouble is experienced. This treatment is usually very successful, especially in cases complicated by the presence of varicose veins.

The treatment recommended by Unna of Hamburg, will be found most useful, especially when the ulcer is associated with varicose veins and the

out of a hot solution of carbolic acid (1 in 20) to disinfect the surrounding skin. The incision may be made with an abscess-bistoury, a Syme's sickle-shaped knife or a scalpel. It should be made either at the point where fluctuation is most distinct, or at the most dependent part, so as to prevent subsequent bagging of the matter. The bistoury should be held short, and introduced perpendicularly. If the depth to be reached be considerable, the blade of the bistoury should be half turned round after its introduction, when the pus wells up by its side if the abscess have been reached, the point at the same time being felt to move freely in the cavity of the abscess. The incision must then be continued for a moderate extent in the direction of the natural folds of the skin of the part if possible, and always parallel to the course of the chief vessels. The healing of the abscess cavity without further suppuration is certainly facilitated by cleaning it out. This should not be done with any sharp scraping instrument lest unnecessary injury be done to the surrounding parts softened by inflammation. The cleaning is best effected by means of a piece of sponge, moistened with a solution of corrosive sublimate (1 in 500). A moderate degree of force may be used in order to remove the superficial layers of the wall of the cavity. The cavity must then be dried by the repeated introduction of fresh pieces of sponge squeezed as dry as possible. This scrubbing the wall of an acute abscess necessarily causes some bleeding, and in large abscesses, or in those in very vascular organs, it is often wiser to omit it, but when it can be done without causing loss of blood, it certainly seems to promote rapid healing. Any bleeding that may occur from the wall of the cavity is very easily arrested by elevation and pressure. No antiseptic seems to arrest suppuration better than the strong perchloride solution (1 in 500), but this must only be used with a sponge, and all excess afterwards removed lest it cause poisoning. If it be thought inadvisable to sponge out the cavity, it may be freely irrigated with some antiseptic solution. The introduction of a small quantity of iodoform is often useful in checking further suppuration.

The abscess cavity having been opened, and cleaned if possible, it is usually necessary to make provision for some future discharge. If this be not done, the lips of the wound tend to stick to each other, and the cavity may become quickly distended with fresh fluid. In small abscesses which have been freely opened the introduction of a small piece of lint soaked in some antiseptic lotion for a few hours will suffice, but if the abscess be deeply seated or of large size a drainage tube should be inserted.

Tents made of plugs of lint and metal drainage tubes were frequently used by the old Surgeons in the treatment of suppurating wounds and deep-seated abscesses, but the methodical use of *Drainage-tubes* was introduced into modern surgical practice by Chassaignac in 1855. The tubes should be made of red india-rubber, which is the most durable, and should have holes cut in them at regular intervals. They should be kept in a solution of carbolic acid (1 in 20) for at least 24 hours before being used, to render them thoroughly aseptic. They must correspond in size to the capacity of the cavity they are intended to drain; not so much because a small tube could not carry off all the fluid that escapes, but because the larger tubes are less likely to get accidentally choked, and the larger the cavity, the more serious would be the consequences of such an accident. A couple of threads, about 2 inches in length, must be attached one to each side of the superficial end of the tube. These lie upon the skin beneath the dressing when the tube has been inserted, and prevent its

[illegible] that the tender spot should be found, and a knife or lancet point [illegible] it, so as to divide the branch of nerve passing to it, a treatment which is often successful.

Inflamed Ulcer.—This is characterised by redness, swelling, heat, and pain in the *surrounding skin*. The *edges* are sharply cut. The *surface* is often of a dark red and dry from stasis in the vessels of the granulations, but later on it becomes covered with a thin yellow slough. The *base* is swollen and oedematous, like the surrounding tissues. The *discharge* is serous and often bloody. In the most acute stage the surface of the sore may be dry, and covered with a thin crust or scab. It arises most commonly in people who drink to excess, and is not unfrequently associated with gout. Any sore may, however, become inflamed if neglected and allowed to become covered with irritating discharges.

The *Treatment* must be both general and local. As a rule, the patients are better for purging. This may usually be effected by a mercurial pill, after which sulphate of magnesia, ʒss, infusion of quassia, ℥i., may be given three times daily for a few days. If the patient be gouty, ten drops of vinum colchici may be added to each dose. Locally the limb must be elevated, and the patient kept in the recumbent position. Hot applications will be found always to give the greatest relief. Hot boric acid fomentations in most cases speedily reduce the pain and swelling. Another excellent application is the following: acetate of lead, ʒss; tincture of opium, ℥ss; water, to ℥viij.; pour a small quantity of the lotion into a saucer and add an equal quantity of boiling water; moisten with this diluted lotion a piece of lint of sufficient size to cover the whole reddened area; apply it warm and cover it with oiled silk, then wrap the whole part in a sheet of cotton-wool. We thus get warmth and moisture, with a powerful astringent and sedative, and experience has shown that the quantity of acetate of lead present is sufficient to prevent any decomposition of the discharges. If preferred, tincture of belladonna may be substituted for the tincture of opium.

Sloughing Ulcer.—When not specific, this is an increased degree of the inflamed variety, usually occurring in feeble or cachectic states of the constitution, and generally accompanied by a good deal of fever. The *surrounding skin* presents an angry, dusky, red blush; the *edges* are sharply cut; and the *surface* is covered with a greyish slough. The *discharge* is serous and offensive; there is a sense of heat and pain, and the inflamed area is acutely tender. The ulceration, unless arrested, spreads rapidly.

Treatment.—The general health must be improved by a nourishing but unstimulating diet, combined with the use of tonics. Opium is of the greatest value. One grain should be given twice or thrice daily. The patient must be kept in bed, and the part elevated. If the surface of the sore be very foul, it may be sprinkled with iodoform, after which hot fomentations must be applied to the whole reddened area. As the inflammation becomes less acute, the warm lead and opium lotion above mentioned may be applied, and when the sloughs have separated, and the surface has become clean, the ordinary treatment of a healthy sore must be adopted. (*See* Gangrene.)

A special form of sloughing ulcer is not uncommonly met with in patients suff[illegible] from *diabetes*. It commences sometimes as a bleb, which bursts and [illegible]rk brown slough, including the whole cutis, but not extending [illegible]e subcutaneous tissue. The slough may very gradually extend.

through the substance of the muscle into the cavity of the abscess, and along the groove of this a slender pair of dressing-forceps is passed : when it reaches the abscess the blades are opened up, the muscular fibres separated, and free exit given to the pus. The opening thus made must be maintained by the insertion of a drainage-tube, or the patient's condition will be but little improved, as the muscular fibres come together again as soon as the dressing-forceps are removed, and proper drainage being thus rendered impossible, the pus will soon re-accumulate, and may decompose and give rise to septic poisoning.

After the opening has been made the cavity left eventually fills up either by the coalescence of the sides or by granulating from the bottom. If from the situation of the opening the cavity does not drain properly but becomes partly filled again with pus, a fresh incision, termed a "counter-opening," may require to be made in the most dependent part.

The treatment of the abscess from the time it is opened till the cavity is closed, is best carried out by the application of some efficient absorbent antiseptic dressing. Any of those mentioned in the preceding Chapter and in that on the Treatment of Wounds may be used.

In cases of acute diffuse suppuration in which it may be wished to continue the application of warmth and moisture after the incision has been made, fomentations of boric acid lint or of salicylic wool will be found most useful. In situations in which it is difficult to apply an efficient antiseptic dressing, as at the margin of the anus, the introduction of a small quantity of iodoform into the cavity will usually act as an efficient antiseptic.

Linseed-meal poultices should never be used after an abscess has been opened or has burst. They encourage putrefaction and suppuration, and often become extremely foul when soaked in pus.

Treatment of Chronic Abscesses.—Chronic abscesses may be treated by Tapping or Aspiration ; by Aspiration followed by injection of some antiseptic fluid, with or without previous washing out of the sac ; by Incision, flushing, and scraping, followed by the injection of iodoform and immediate closure of the wound ; by Incision and drainage ; and, lastly, by Excision of the sac.

Simple Tapping or *Aspiration* seldom effects a cure, but may occasionally be adopted as a palliative treatment in very large chronic abscesses, especially when the patient is dying from tuberculous or other chronic disease, or the Surgeon is temporarily placed in circumstances which make more efficient treatment impossible. One tapping will often delay the bursting of the abscess, with its attendant dangers, for many weeks.

Tapping is best done by means of the aspirator, the method of using which has already been described (p. 258). A large needle should be used, as the pus is often too thick to flow through a small one, and even then the operation often fails owing to the presence of curdy matter, which chokes the needle. If any pus has entered the syringe, the needle may sometimes be cleared by forcing some back through the needle, but if it becomes choked again at once, some other method of treatment must be adopted. If the pus comes freely through the needle, the aspiration should be continued as long as it flows, or until it becomes darkly stained with blood. During the aspiration the needle should be kept perfectly steady, to avoid any needless damage to the wall of the abscess, and all squeezing should be avoided, as the pressure of the atmosphere

the ulcer heal, it constantly breaks open again; or hæmorrhage may occur from a ruptured vein on its surface. Other means, which will be described in a future chapter, must then be taken for the permanent occlusion of the varicose vessels.

Ulcers on Mucous Membranes.—Various forms of ulcer occur upon mucous membranes, especially those of the throat, rectum, and genital organs. As these, however, are commonly specific, they will be described hereafter.

Ulcers of mucous membranes, when not of a specific character, present the general appearances characteristic of the cutaneous healthy, inflamed or weak varieties, and require the topical applications which have been described as suited to these conditions; though generally they will demand the free employment of caustics, or astringents, especially of the nitrate of silver.

A. E. Barker. Some iodoform emulsion may be injected before the incision is closed with sutures. The flushing and scraping must be performed with care, and the Surgeon must avoid tearing through the bands, which are often felt crossing the cavity, as these may contain vessels of considerable size. The profuse capillary hæmorrhage which sometimes occurs from the wall of the abscess may be arrested by firm pressure.

Incision and Drainage is the mode of treatment which becomes necessary sooner or later in many cases. It should, however, as far as possible, be reserved for cases in which the methods already described are not available or have failed. The dangers attending the opening of a large chronic abscess, should putrefaction of the discharges follow, have already been pointed out. Efficient antiseptic means must be adopted to prevent this accident, and if from any cause this be not possible, the dangers that follow the admission of air may be greatly reduced by making free incisions and inserting large drainage-tubes, so that the quantity of decomposable matter shall be reduced to a minimum.

If a chronic abscess has been opened and, either from neglect of antiseptic

Fig. 96.—Two forms of Volkmann's "Sharp Spoon."

precautions or failure of the means adopted, the discharges become offensive, the patient's life may be endangered either by the profuseness of the suppuration or by the absorption of the products of putrefaction. In these circumstances if the abscess has been opened by a small wound not larger than is required for the insertion of the drainage-tube, it is wiser, if possible, to enlarge the wound, or if this be not possible, to make a free counter-opening. In this way by establishing perfect drainage, the danger of septic poisoning is greatly lessened. At the same time the cavity may be cleaned out with a sponge soaked in a solution of chloride of zinc (40 gr. to ℥j.), and the raw surface dusted with iodoform, after which an antiseptic dressing may be applied. It is possible sometimes in this way to render the cavity perfectly aseptic. The immediate effect of this proceeding is usually to cause an elevation of temperature, soon followed by a permanent fall. This mode of treatment is specially applicable to chronic abscesses connected with joints.

If the cavity be of great size and deeply situated as in the case of a psoas or lumbar abscess, complete disinfection is extremely difficult. The abscess may be washed out by injection of some antiseptic solution, such as Condy's fluid, carbolic acid lotion (1 in 40), corrosive sublimate (1 in 2000), or boric acid, and by this means the offensive smell of the discharge may be diminished; but the suppuration is kept up, or even increased, by the repeated application

of these irritating fluids, and at the same time, if they are discontinued, the signs of putrefaction soon return. Callender pointed out that this is in many cases due to the irregularity of the cavity and the impossibility of making the antiseptic reach every part of it, and he therefore recommended that the fluid should be pumped in at some degree of pressure, so as completely to distend the sac. After this has been done, some antiseptic dressing may be applied. The injection must be done under an anæsthetic, so as completely to relax the parts round the abscess. This treatment has been followed by very good results. The solution Callender used was the 1 in 20 carbolic lotion diluted with half its bulk of hot water. A very dilute solution of iodine has also been used with good results. Chloride of zinc, 40 grains to the ounce of water, has been employed for the same purpose ; but it is a dangerous remedy, as in that strength it is powerfully caustic and can be safely applied only with a sponge as above described. In injecting an abscess-cavity with any antiseptic solution, great care must be taken not to use too much force, or the sac may be ruptured and the fluid diffused in the areolar tissue, an accident which might be fatal, especially if the stronger antiseptics were being used. Another plan recommended, is to introduce iodoform into the cavity by means of a brush, or on the end of the drainage-tube, or by injecting it as an emulsion with glycerine and water. It must not be forgotten, however, that iodoform dissolves very slowly and adheres to the wall of the abscess, so that if some is introduced daily, it may accumulate until a quantity is present sufficient to give rise to symptoms of poisoning. A case of this kind occurred in University College Hospital, which nearly proved fatal before the cause of the strange symptoms from which the patient suffered was discovered and removed.

Excision of the whole abscess wall, when such treatment is possible, is undoubtedly the best mode of curing many chronic abscesses. In the chronic mammary abscess the removal of the thick fibrous wall greatly hastens the cure. In tuberculous abscesses the same treatment is often possible, as in those connected with joints and superficial bones. The removal of the sac of the abscess is most easily done by careful dissection with forceps and scalpel or scissors, the part being made bloodless by Esmarch's method. The bleeding is easily arrested by pressure and elevation of the limb.

Constitutional Treatment of Suppuration.—With the view of preventing the occurrence of suppuration, the Surgeon must be careful to maintain the powers of the system, and not to reduce the patient too much, even if the inflammation be of an acute character at the outset. Suppuration is a condition of debility, and is especially predisposed to by any previously existing enfeebled state of the system, or by malnutrition. Another reason for the avoidance of the early employment of debilitating means is that, if suppuration once be established, the drain on the system may eventually be so considerable as to require all the patient's powers to enable him to bear up against it. While the abscess is discharging, nourishing, tonic, and even stimulating treatment will be required in proportion to the amount of debility that is induced. Amongst the most useful medicinal agents are mineral and vegetable tonics, the mineral acids, and cod-liver oil in the more chronic stages. Attention to hygienic conditions, with change of air, and residence at the sea-side, are also valuable. Should hectic come on, the same general tonic plan must be adopted, while we have recourse to means adapted to meet the local

symptoms. Thus, acids are required to check the sweating, astringents to arrest the diarrhœa, and as much mild nourishment as the patient will bear to support the strength.

HÆMORRHAGE INTO THE CAVITY OF AN ABSCESS is not of unfrequent occurrence. It may arise from three sources: 1. Oozing of blood from the vascular wall of the abscess: 2. Ulceration into a vein; 3. Ulceration or sloughing of the coats of a neighbouring artery.

The **bleeding** which occurs **from the abscess-wall** is the most frequent, and the least important. It sometimes takes place before the abscess is opened, the pus that escapes being then found to be sanious and mixed with small coagula. More commonly it occurs after the opening of the abscess, in consequence probably of the wall having lost the support of the contained pus, when the vessels in the soft tissues give way and the cavity speedily fills with blood. In these cases the hæmorrhage may be arrested by laying the cavity of the abscess freely open and turning out the coagula, when the bleeding usually ceases as soon as the interior is exposed to the cold air. Should this fail, it may be necessary to stuff the cavity with some antiseptic material as iodoform- or salicylic-wool, and to apply pressure with a bandage. When the cavity is closing, the vascular granulations which form upon its walls may bleed very freely if any pressure be accidentally brought to bear on the veins leading from the part. In this case the bleeding ceases immediately the pressure is removed.

Hæmorrhage from **Ulceration extending into a neighbouring Vein**, is necessarily far more serious. It has usually happened from sloughy abscesses, formed in the neck as a consequence of scarlatina in strumous and unhealthy individuals, opening up the internal jugular vein. But it may arise, independently of any specific inflammation, in cachectic patients. In these distressing cases, the only treatment that can be adopted is, to plug the cavity of the abscess. In this way the fatal event may be for a time perhaps delayed; but it is inevitable ultimately, the blood bursting forth by the sides of the plugs as these become loosened, or as the sloughing opens up the vein more widely.

If the hæmorrhage arise from the **Ulceration of a large Artery**, the case necessarily becomes one of extreme urgency. I have known this condition to occur in the neck and in the thigh; in the neck from sloughy scarlatinal abscess implicating the carotid; in the thigh, from the extension of ulceration from abscesses and sinuses to the deep femoral. When this untoward complication of abscess occurs in the neck, the hæmorrhage is usually so sudden and so profuse that the Surgeon has not time to tie the carotid before life is extinguished. A. J. Pepper has, however, recorded a case of severe hæmorrhage after scarlet fever, which was repeated several times, and finally successfully arrested by ligature of the common carotid. The patient was a man, aged 30, and made a good recovery. In the thigh the case is not so urgent. Warnings by repeated small hæmorrhages may have enabled the Surgeon to adopt means to restrain the bleeding; and, in the case to which I allude, that of a young man, the femoral artery was tied successfully.

SINUS AND FISTULA.—After an abscess has been opened, its cavity may not fill up completely; but, contracting into a narrow suppurating track, it may form a canal without disposition to close, from which a small quantity of pus constantly exudes, thus constituting a **Sinus** or **Fistula.**

A *sinus* is a suppurating track penetrating to a greater or less depth an
the tissues, closed at its deep end, and opening on the surface of the bo
fistula is an abnormal communication between two of the cavities of the
or between a cavity and the surface, or a track through which the secre
some gland or hollow viscus takes an unnatural course. Thus we tal
sinus leading down to dead bone, but of a recto-vesical fistula, an aërial
a urinary fistula, &c.

The *Causes* of this non-closure of an abscess may be referred to the fol
heads: 1. The presence of a foreign body, as a piece of dead bone;
passage of irritating matters, as urine, fæces, saliva, &c., through the al
3. The contraction of neighbouring muscles; as when the abscess is
neighbourhood of the sphincter ani, and as occasionally happens in ab
about the limbs; and 4. The presence of an insufficiently drained ca
the bottom of the sinus.

The orifice of a sinus or fistula when situated in hard and condensed
is often very small, depressed, and perhaps covered by a scab. In soft
it is commonly large and widely open; when communicating with bone
are usually soft, florid granulations obstructing it.

Structure.—A sinus consists of a narrow channel, often long and wi
having an external orifice usually somewhat protuberant, and situated
or among loose florid granulations. The walls of this channel, whi
always indurated, are lined by a layer of imperfectly-formed granul
exuding pus. If the orifice be occluded, this pus will collect within the
and, distending its walls, reconvert it into an abscess. In structure, the
a sinus may be said to be a long, narrow, chronic abscess, with a per
external aperture.

The granulation-tissue of a sinus, like that of any other granulatin
contracts in healing, and consequently a healed sinus leaves a deep
in the skin. This is the best evidence of thorough healing; a sinu
always be expected to break open again if it skins over superficially w
dimpling.

A fistula may differ in no respect from a sinus when its length is co
able, as in many anal and urethral fistulæ, but when it forms merely
communicating channel between two cavities, as between the rectu
vagina, or between the surface and a cavity or duct, as in a trach
salivary fistula, the granulations may become completely covered by epit
continuous with that on each side, and no cure is possible till this has b
away or destroyed.

The **Treatment** of a sinus or fistula has reference to its cause in t
instance; for, until the foreign body or the insufficient drainage that k
open and maintains the discharge has been removed, it will be use
attempt its closure. After the removal of the obstacle to healing, w
endeavour to procure obliteration of the sinus by one of three methods.

1. *Pressure*, by means of a roller and graduated compress, so as t
adhesion of its opposite sides, is useful in those cases in which the s
recent, without much surrounding induration, and so situated, as up
trunk, that pressure can easily be applied.

2. A more healthy condition may often be produced in the sinus by
ing it from time to time with "red wash," or with tincture of iodine,
introduction of iodoform in crystals by means of a catheter or by

bougies such as are used in the treatment of gonorrhœa; by passing a probe coated with nitrate of silver to the bottom; by inserting a drainage-tube.

3. *Scraping away* the callous and imperfectly granulating sides of the sinus by means of a small sharp spoon (Fig. 96), or destroying them by means of a red-hot wire or the thermo-cautery, is a very efficacious means of setting up a new and healthier action in the part, and so bringing about closure of the canal. The galvanic cautery will often be found most convenient, as the wire can be introduced cold and heated *in situ*, and the danger of wandering from the track of the sinus is thus avoided.

In many cases, scrubbing with a sponge soaked in a solution of chloride of zinc (40 gr. to ℥j.), and held in a pair of forceps, is very useful.

4. The last method consists in *laying open the sinus* from end to end, and then dressing the wound so that it may heal from the bottom; in this way neighbouring muscles, that have kept it open by their contractions, may also be set at rest. The division of the sinus should be made with a probe-pointed bistoury, introduced through the external opening either by the aid of a director or without such assistance. The operation should be done effectually, the sinus being followed as far as is prudent, and laid open as completely as possible. Some fistulæ, as the fistula in ano, require similar treatment.

5. Fistulæ which are lined by a complete epithelial covering, as many vesico-vaginal, recto-vaginal, and recto-vesical fistulæ, can be cured only by destroying this, either by cutting or scraping it away, or by cauterisation. Many such fistulæ require plastic operations for their cure.

CHAPTER VI.

ULCERATION.

Ulceration is a progressive destruction of the tissues, in which the solid parts seem to melt away into a liquid discharge without the separation of visible portions of dead tissue. The meaning of the term will be made more clear by a few examples. If a piece of skin be killed, as by a caustic, or by mechanical violence, there is at first no solution of continuity, the dead tissue is everywhere continuous with the living; but within a few hours the phenomena of inflammation manifest themselves in the surrounding living tissues, thus imperfectly marking out the limits of the part that is killed. By about the second or third day the line between the dead and living becomes more clearly defined, the cuticle at the margin of the living part becomes loose, and is raised by fluid beneath it, and at last comes away, exposing a narrow raw surface discharging pus; the living tissues which lie in immediate contact with the dead then seem gradually to melt away into the purulent discharge till a complete solution of continuity is established, the dead part, or "slough," being loosened and finally cast off. This process, by which a slough is separated from the parts beneath, takes place entirely at the expense of the living tissues; it is spoken of as ulceration, and the sore left is called a **simple ulcer.**

The effect produced by the inoculation of the poison of a soft chancre forms another excellent example of ulceration. Within twenty-four hours of the inoculation a small inflamed spot appears, with redness, swelling and itching: by the third day the cuticle is raised by a drop of pus; when the thin epidermis is removed a small red sore is seen, from which pus exudes: this slowly extends, the discharge being purulent, and at no time do any visible portions of dead tissue come away with it; the surrounding tissues show the ordinary signs of inflammation. Such a sore is a **specific ulcer**, the irritant which causes it being a specific poison.

A third form of ulceration, differing essentially from the two preceding, is seen in the later stages of the growth of malignant tumours. Thus an epithelioma commences as a small hard growth, which infiltrates the surrounding tissues. By the pressure of the growth which forces its way into the interstices of the structures which it is invading, the original tissues become absorbed, and the cancer-tissue comes to occupy their place. When the growth reaches a certain size its central parts degenerate, soften and break down, and a loss of substance takes place. As the disease progresses the surrounding tissue becomes invaded and destroyed by the cancerous growth, which in its turn breaks down and melts away superficially. Thus the most extensive destruction may take place. This process is described as ulceration, although here there may be no true inflammation, and the resulting sore is called a **malignant ulcer**.

All these forms of ulceration have one feature in common: the original

tissues are first infiltrated by cells foreign to the part, which destroy them and occupy their place; then in their turn the new cells perish, and are thrown off superficially with a fluid discharge, and thus a progressive destruction of tissue takes place. In the first two examples the invading cells are the leucocytes which have migrated from the blood vessels, and in the last they are the special cells of the malignant growth.

In the present chapter we have to deal only with ulceration as it occurs as a part of the process of inflammation.

An ulcer passes through two stages, viz. 1. Extension; and 2. Repair. To the former of these only is the term "ulceration" applied.

PATHOLOGY.—The process of ulceration when dependent on inflammation hardly needs a detailed description, as it differs in no essential feature from that already described as taking place in the formation of an abscess, the only variation being that in the latter case the formation of pus and destruction of tissue take place in a closed space, while in the former they occur upon a surface. The separation of a dead piece of tissue from the surrounding living parts is thus accomplished. The tissue immediately in contact with that which is dead must necessarily have suffered to some extent from the injury which has caused the mischief, and its vitality thus being lowered, the phenomena of inflammation are manifested in it with an intensity corresponding to the degree of damage, and consequently diminishing as we recede from the parts that have been actually killed. Where the living tissues touch the dead the condition of stasis will be reached, and those vessels which pass from the dead to the living tissue will become plugged with clots extending as far as the next branch in the living parts. Beyond the area of stasis we find that of retarded flow, accumulation of leucocytes, and migration; and, beyond this again, that of simple dilatation with increased rapidity of flow. The width of the area in which these inflammatory phenomena take place varies greatly. It may be merely microscopic, as in the separation of a piece of dead tissue which has been prevented from decomposing by antiseptic treatment, or it may extend for half an inch or more. Occasionally these vascular conditions can be recognised clinically by the effect produced by the pressure of the finger; in the area of fluxion it is scarcely possible to remove the finger before the brilliant red colour has returned; in that of retarded flow a second or more may elapse before the pale mark made by the finger has regained its red colour, and the tint in this area is a more dusky red than in that of fluxion: sometimes small red dots may be noticed in the pale patch formed by the pressure of the finger, indicating points at which some red corpuscles have escaped from the distended vessels. Lastly, close to the dead tissue is a dark red line unaltered by pressure, indicating the area of stasis and thrombosis, in which also many red corpuscles have escaped from the damaged vessels. From the vessels in the stage of retarded flow abundant exudation of blood-plasma and migration of the corpuscles take place. The wandering cells move in great numbers into the passive layer of tissue touching the dead part, and by their pressure destroy such remains of vitality as may be left; the original tissue softens and disintegrates, its place becomes occupied by closely-packed leucocytes; the leucocytes in contact with the irritating dead tissue in their turn degenerate, and becoming granular and losing their adhesion, are separated from each other by the serous exudation from the neighbouring vessels, and thus pus is formed and the process of separation is completed. When this has

taken place a surface is left covered superficially by a uniform layer of closely packed cells derived from the white corpuscles which have migrated from the vessels. Such a surface is a simple ulcer. The dead tissue which acted as a foreign body being removed, if no further source of irritation be present, the surrounding tissues recover from their impaired vitality, the inflammation subsides, migration ceases, and the process of **repair** commences. This process will be described in the next chapter with repair in general. (*See* Union by the Second Intention).

Ulceration, as it occurs from the inoculation of a specific poison, as in the example of the soft chancre before given, differs in no respect from that just described, except that at no time is there a visible piece of dead tissue cast off, and that the irritant which causes the process is developed persistently in the discharges, and, unless it be in some way destroyed, may continue to maintain the destructive process almost indefinitely. It is evident that if the irritating virus developed in the sore is of sufficient intensity, it may cause death of the tissues before the process of absorption of the original structures and substitution of a mass of leucocytes for them has had time to be completed. It is under these circumstances that ulceration merges into spreading gangrene, the tissues no longer appearing to melt away in the liquid discharges, but remaining as a soft, partially disintegrated slough on the surface of the sore.

The process of formation of an ulcer in skin which has long suffered from chronic inflammation has been well described by Billroth. "Let us suppose," he says, "that we have a chronic inflammation of the skin of the leg, say on the anterior surface of its lower third. The skin is traversed by dilated vessels, hence it is redder than normal; it is swollen, partly from serous, partly from plastic infiltration: and it is sensitive to pressure. Wandering cells are infiltrated, especially in the superficial parts of the cutis: this renders the papillæ longer and more succulent; the development of the cells of the rete Malpighii also becomes more plentiful, and its superficial layers do not pass into the normal horny state; the connective tissue of the papillary layer is softer, and becomes partly gelatinous. Now, slight friction at any point suffices to remove the soft, thin, horny layer of the epidermis. This exposes the cell-layer of the rete Malpighii; new irritation is set up, and the result is a suppurating surface, whose upper layer consists of wandering cells, the lower of greatly degenerated and enlarged cutaneous papillæ. If at this stage the part were kept at perfect rest, and protected from further irritation, the epidermis would be gradually regenerated, and the still superficial ulcer would cicatrise. But usually the slight superficial wound is too little noticed, it is exposed to new irritations of various kinds; there are suppuration and molecular destruction of the exposed inflamed tissue, then of the papillæ, and the result is a loss of substance which gradually grows deeper and wider: the ulcer is fully formed."

Causes.—*The conditions essential to ulceration* are:—1. An irritant acting on a limited portion of the living tissues with sufficient intensity to cause the stage of retarded flow in the vessels with abundant migration of leucocytes, culminating in stasis and death in the parts most directly acted on. 2. A persistent action of the irritant for a sufficient time.

We have before seen, in the Chapter on Inflammation and Suppuration, that the effect produced on a living tissue by an irritant depends partly on the intensity of the irritant itself, and partly on the power of resistance of the

tissues, or, in other words, their degree of vitality. Consequently, the causes of ulceration, like those of inflammation in general, are divided into **Predisposing**, or those which render the tissues liable to suffer severely from injurious influences by impairing their vitality; and **Exciting**, or, in other words, the injurious influences themselves.

Predisposing Causes.—Everything that acts as a predisposing cause of inflammation is also a predisposing cause of ulceration (see p. 172), and the following may be mentioned as amongst the most important. They are chiefly conditions that interfere in some way with the nutrition of a part. A feeble circulation, such as often exists in the lower limbs, in the alæ of the nose, and in newly formed or recently cicatrised tissues, predisposes to the formation of ulcers. As age advances, nutrition becomes impaired and the circulation less active, and slight causes suffice to lead to disintegration of the structure of a part. Hence we commonly see ulcers of the legs in elderly people, more particularly amongst the poorer classes, arising from slight irritation or pressure. Parts cut off from connection with a healthy nerve-centre ulcerate readily, as the nates in paraplegia.

Tissues that have been passively congested for a long time are apt to inflame under the influence of some trifling exciting cause, and to run rapidly into ulceration. This usually commences in the centre of the part, where the nutrition is lowest; here a small sore forms, which exudes thin unhealthy pus, and rapidly extends. So long as the sore is inflamed, it continues to spread, and repair cannot take place. In some cases in which, from the above causes, the vitality has been greatly lowered, the exciting cause which is sufficient to give rise to ulceration may be so slight as to escape detection. This is especially marked in scrofula, scurvy, and syphilis. In many forms of tuberculous and syphilitic ulceration the process resembles in many respects that of malignant ulceration—the chronic inflammatory products first forming a solid mass of very slow growth, almost like a tumour, which ultimately degenerates and softens in the centre, and is discharged superficially, leaving a raw surface, which slowly spreads by ulceration. These form a connecting link between simple inflammatory ulceration and ulceration from malignant growths.

Exciting Causes.—The direct exciting causes of ulceration act chiefly on the skin and mucous membranes, and are very various in character :—

1. The most rapidly spreading forms of ulceration arise from specific infective poisons, as in phagedænic ulcers, hospital gangrene, soft chancre, the sore throat of scarlet fever, and in many syphilitic ulcerations. Most of these, at the same time, cause acute inflammation, extending to some distance beyond the area in which destruction of the tissues is visibly taking place. In such cases the action of the irritant may be so acute, and the destruction of the tissues so rapid, that the migratory cells may not have completely displaced the original structures before disintegration occurs. Microscopic shreds of the dead tissues are then to be found in the pus, which contains fewer genuine pus-cells and assumes often the form of a dirty brownish fluid, discoloured by the broken-up red corpuscles from the disintegrating layer of tissue. When the irritant is more potent still, and penetrates into the surrounding parts, destroying them rapidly before any extensive migration has had time to take place, layers of disorganised tissue constituting "sloughs" are formed, which completely cover the surface, and the discharge may be merely serous fluid, scarcely

turbid with cells. The whole process thus merges into gangrene. No sharp line can be drawn between spreading gangrenous inflammation and ulceration, and we call the intermediate conditions by such names as sloughing, gangrenous or phagedænic ulceration.

2. In parts which have long suffered from chronic inflammation, slight mechanical and chemical causes give rise to ulceration.

3. Ulceration sometimes commences in the crypts, or follicles, which open on mucous surfaces, as a consequence of catarrhal inflammation, with accumulation of secretion within their cavities. It leads to the formation of circular depressed ulcers.

4. In some general diseases, accompanied by the formation of vesicles or pustules on the cutaneous surface, ulcers may be left when they burst, as in small-pox, pemphigus, syphilitic rupia, and occasionally in chicken-pox.

5. Any injurious influence, whether chemical or mechanical, which causes the death of a part, necessitates the occurrence of ulceration for the separation of the dead tissue, and the sore so left is an ulcer. Long-continued pressure is a common cause.

6. In some specific cases, as before stated, ulceration is preceded by the formation of a morbid growth, as a syphilitic gumma, tubercle, or a malignant tumour.

Situation.—Ulcers may be situated upon any part of the cutaneous surface as the result of loss of substance from wound or other injury. Syphilitic or strumous ulcers may appear on almost any part either of the skin or the mucous membranes, but they most frequently occur in particular situations, as on the penis, lips, tongue, or rectum. Of all forms, however, perhaps the most common with which we have to deal, is the simple ulcer of the leg, so frequently seen in hospital out-patient rooms. The lower half of the leg is the usual seat of these simple ulcers, the skin of that part being much exposed to mechanical violence, and very prone to congestion from position, from varicose veins, and from its great distance from the centre of circulation. In advanced life, moreover, degenerative changes in the arteries of the leg obstructing the flow of blood are very common. Ulcers that form here are slow in healing, and very likely to recur, because the conditions that led to their formation may still exist; also there is often but a very thin layer of subcutaneous fat between the skin and the tibia, and, consequently, there is a great tendency for the under surface of the scar to adhere to the bone.

General Treatment of Ulceration.—In the **Local Treatment** of ulceration, the Surgeon must be guided by the special conditions presented by the ulcer, as presently described; but there are some points which demand attention in all cases. 1. Every source of irritation which could cause inflammation, or maintain it if present, must be carefully removed; for while inflammation is present no proper reparative process can go on. Thus, if the ulceration be due to the presence of a specific poison, as in the case of a soft chancre, this must be destroyed by antiseptic or caustic applications. In simple sores the surface must be preserved from friction, the part must be kept at rest, and the decomposition of the discharges must be prevented by proper applications. 2. The circulation must be maintained in a normal state, both congestion and local anæmia being guarded against; as, without a normal supply and a sufficiently rapid change of blood, the growth of the reparative tissue cannot take place. Constriction must therefore be avoided, and the

part must be placed in such a position as will favour the return of blood from it. 3. Proper local applications adapted to the nature of the case must be employed, conjoined with uniform pressure, to support the dilated and weakened vessels of the part.

The **Constitutional Treatment** must be carefully attended to. Unless this be done, the best regulated local measures may be employed in vain. Attention to the digestive organs, and improvement of the constitution, if it be strumous or syphilitic, will do more in these cases than any other means can accomplish. The nutrition of the patient requires due care.

VARIOUS FORMS OF ULCERS.

When ulcers occur in the skin, as the result of non-specific disease, they may be arranged under the following heads: the Healthy; the Weak; the Indolent; the Irritable; the Inflamed; the Phagedænic or Sloughing; and the Varicose. Besides these varieties, each of which is marked by distinct characteristics, various other forms of ulceration depending on specific causes, as the Syphilitic, Tuberculous, Lupoid, Cancerous, &c., are met with; all of which will be treated of in their special chapters.

The varieties presented by ulcers are by no means dependent on local conditions merely, but are in a great measure owing to constitutional causes. Indeed, the aspect of the ulcer, and the character of its granulations and of its discharge, are excellent indications of the general condition of the patient as well as of the local disease.

In studying an ulcer clinically, we have to pay attention to the following points: 1. The surrounding skin. 2. The edges of the sore. 3. The surface of the sore. 4. The base of the sore. 5. The nature of the discharge; and 6. Pain and tenderness.

The Healthy Granulating Sore.—The *surrounding skin* is free from œdema; there is no change in it beyond slight hyperæmia close to the margin of the sore; *the edges* are regular in outline, shelve gradually down to the surface of the sore, and are marked by three zones of colour, an outer opaque white, a middle opalescent blue, and an inner dark red, as described in the chapter on Repair. *The surface* is slightly depressed, and thickly studded with florid red granulations, firm in structure and uniform in size, each being about as large as half a mustard seed. *The base* of the sore is soft, and not adherent to deep-seated structures, as bones or fasciæ. The *discharge* will, under ordinary circumstances, be thick, creamy, laudable pus; but by carefully excluding every source of irritation, it may be made to assume a more or less serous character. There is no *pain or tenderness*. It is the object of our treatment in all cases to bring the other forms of ulcer into this condition.

Treatment.—In the management of the healthy granulating sore, the treatment should be as simple as possible; the application of some simple dressing and the pressure of a bandage usually enable it to cicatrise. Perhaps the best of all antiseptics for this purpose is a concentrated solution of boric acid. A piece of lint exactly the size of the sore is moistened with the lotion and put on the surface; over this must be placed a piece of oiled silk or thin guttapercha tissue, overlapping the lint in all directions for about

one-eighth of an inch. Uniform pressure is secured with a bandage, and the dressing must be changed at least daily.

Boric acid lint, wetted with the lotion, may be applied to foul sores in the same way; when the sore becomes perfectly healthy and free from decomposition, its surface may be protected from the direct action of the antiseptic by covering it with the green oiled silk dipped in the lotion before being applied; over this the boric acid lint may be placed either wet or dry to absorb the discharge. Another excellent application to a healthy ulcer is the boric acid ointment spread on thin muslin, the whole being dipped in the lotion to make it apply itself smoothly before being put on the sore: over this may be placed a pad of salicylic wool to catch the discharge, the whole being secured by a bandage.

Carbolic acid solution (2 per cent.) has the great disadvantage of being irritating when first applied, and, as the acid becomes rapidly volatilised, it soon becomes inefficient.

If, from any reason, it may be considered desirable to dress the sore less frequently, a more lasting dressing may be applied thus: wash the sore and the surrounding skin well with a solution of carbolic acid (1 in 40); put on a piece of the protective green oiled silk, completely covering the raw surface, and then apply the carbolic gauze dressing, as described in the Treatment of Wounds (Chap. IX.). If economy be of consequence, one layer of gauze may be applied to keep the leg clean, over this may be placed a thick pad of carded oakum, and the whole covered by a common bandage. If the carbolic acid gauze irritate the skin, its place may be taken by eucalyptus gauze, or the part may be enveloped in a sheet of iodoform wool, salicylic wool or some absorbent mercurial dressing. By any of these modes of treatment it is possible to get the ulcer into so clean a state, and so far to diminish its discharge, that it shall not be necessary to change the dressing more than once a week. It will be observed that the object of these modes of dressing is to protect the sore from every possible source of irritation, including not only the products of putrefaction, but also the antiseptic agent which is employed to prevent decomposition. Sometimes, however, as has already been stated, the healing process is retarded or arrested in consequence of the extent of the ulcer. In such cases, the transplantation of cuticle will, by affording centres of cicatrisation, expedite the cure.

Whatever mode of treatment be adopted, if the ulcer be on the leg, rest in bed with elevation of the limb has more influence than any other condition in hastening the cure.

Skin-Grafting.—The fact that freshly separated parts if immediately re-applied to a raw surface may contract adhesions to it and retain their vitality was demonstrated long ago. Hunter showed that teeth could be successfully transplanted, and that the spurs of a young cock could be "made to grow on his comb;" Walther that the button of bone removed by a trephine, if reinserted, will contract fresh adhesions, and many Surgeons had recorded cases of adhesion of freshly separated portions of the nose or chin. But little practical use was made of these observations till Reverdin suggested in 1869 that transplanted cuticle might be used to hasten the cicatrisation of granulating surfaces.

The growth of new epithelium over the surface of a sore takes place from the epithelial cells at its margin; and Reverdin showed that by planting small

islets of freshly separated cuticle on the granulating surface, each can be made to form a centre for the development of new epithelium, which, spreading in all directions, coalesces with that growing from the surrounding skin, and thus rapidly covers the sore. The covering of the surface with epithelium is, however, only a part of cicatrisation, the contraction of the granulation-tissue and its development into fibrous tissue forming an equally essential process. The hopes that were entertained at one time, that by the grafting of cuticle the contraction of the scar, which causes such extensive deformity in the case of large burns, could be prevented, have been but imperfectly realised. The process of grafting, in fact, in many cases amounts to little more than dressing the sore with cuticle, if such an expression may be allowed, the new epithelium cells growing over the surface long before the development of the fibrous tissue of the scar has made any appreciable progress. In such cases the cicatrix formed is very weak and apt to break down—much more readily than the scar produced by the natural process of healing. Moreover, even after successful grafting, much contraction frequently takes place as the granulation-tissue becomes completely developed into fibrous tissue. Still, however, transplantation of cuticle is of great use in promoting the healing of large sores; and probably, although it does not prevent the subsequent contraction, it does in some cases lessen its amount.

The process of transplantation of cuticle is as follows: If the sore be not aseptic, it should be dressed every four hours with boric lint moistened with a concentrated solution of boric acid. In about forty-eight hours the sore will be free from septic matter. A piece of skin on some sound part of the body—the outside of the arm, for instance—about the size of an oat, is pinched up with a pair of forceps, and snipped off with curved scissors. The whole thickness of the skin need not be separated, but merely the cuticle down to and including the papillary layer of the true skin, so as just to draw blood. The operation, when properly performed, is almost painless. The little patch of cuticle is now placed, with the raw side downwards, on the surface of the ulcer, care being taken not to injure the granulations in so doing. It is better to apply several small grafts of skin than one large one. Each graft is now covered with a small piece of "green protective," and the ulcer is dressed with a thin layer of boric acid ointment spread on muslin, and dipped in boric acid lotion before being applied. Over this again must be placed a thick layer of iodoform or salicylic wool. The dressing may then be left undisturbed for four days.

It frequently happens that by the third or fourth day the graft has entirely disappeared, but becomes again recognisable a few days after. This is due to the desquamation of the opaque corneous layer of the transplanted cuticle leaving only the thin transparent Malpighian layer behind; the reappearance of the graft takes place as soon as sufficient new epithelium has grown to be again opaque.

For the success of this little operation, it is necessary that the granulating surface, on to which the transplantation is made, should be a healthy one, and that the process of cicatrisation should have commenced at its edges.

When many grafts are required, and especially if the patient be old or nervous, it may be convenient to obtain some from another person. It must not be forgotten that syphilis may be communicated in this way if the grafts are taken from a person suffering from that disease in its active stage. Deubel

records a case in which, to repair great loss of skin from gangrenous erysipelas in an old man, grafts were taken from his son. The treatment was apparently successful, and complete healing took place, but soon afterwards spreading ulcers formed, and the whole scar was destroyed. Roseola appeared ten weeks after the first graft was applied, and was followed by mucous tubercles in the mouth. The son was found to have condylomata about the anus, and had suffered eighteen months before from a hard chancre.

The method of skin-grafting recommended by Thiersch is now largely employed in the treatment of granulating surfaces. It is performed as follows: The granulations are scraped away to the firm underlying tissue, and the hæmorrhage arrested by sponge-pressure. The grafts are made by cutting the thinnest possible slices with a broad, flat razor from some part of the patient's body, preferably the outer surface of the forearm or the front of the thigh. Strips measuring four inches in length and three-quarters of an inch in breadth can thus be obtained, and will live if applied to the raw surface. The grafts should be made slightly to overlap each other as well as the edges of the raw surface, and the latter, if of only moderate size, can be thus completely covered. The whole is covered with protective oiled silk, and a gauze dressing applied. The surface from which the grafts are removed is rapidly covered with epithelium, as in the healing of a burn of the third degree (see p. 393). The healing produced by Thiersch's method is permanent, because the weak granulations are scraped away, and, for the same reason, the contraction of the cicatrix is much diminished.

Operation wounds, which it is found impossible to close by suturing, can be treated in the same way; thus, Watson Cheyne has successfully used the method after excision of the breast in cases where free removal of skin was necessary, the skin grafts being placed on the surface of the pectoral muscle.

True Skin-Grafting, that is to say, the transplantation of portions of the complete thickness of the skin, has frequently been performed for the restoration of portions of lost skin from the face. The details of this operation as it is performed for ectropion will be found in the chapter on Plastic Surgery (Chap. LVII.). It is essential that every vestige of subcutaneous fat should be removed from the under surface of the cutis, otherwise it will almost certainly fail to unite in its new situation. Skin transplanted in this way will adhere either to a fresh raw surface or to a granulating sore, but much more readily to the former. R. C. Lucas has shown that the skin of the prepuce, being devoid of fat, makes excellent grafts for a granulating sore. In hospital practice the opportunities of obtaining the necessary material are very frequent, and may often be taken advantage of in the treatment of the large granulating sores left after burns.

Weak Ulcer.—This most commonly occurs from emollient applications having been continued too long, and especially from the application of poultices. It differs from the healthy sore in that the *edges* want the healing line, and the *surface* is raised above the surrounding skin and covered by flabby semi-transparent granulations sometimes rising in exuberant, gelatinous masses above the edges of the sore. These granulations have a feeble vitality, and readily slough. Popularly they are spoken of as "proud flesh."

The *Treatment* consists in keeping the part elevated and carefully bandaged, and applying an astringent dressing to the sore, such as the "red wash," or

a weak solution of the sulphate of copper. Red wash is prepared according to the following formula: Sulphate of zinc, sixteen grains; compound tincture of lavender, two drachms; water, eight ounces. It will be found a most useful application. The granulations may also be touched from time to time with nitrate of silver. Creolin will be found a useful application in some cases (p. 210).

Indolent or **Callous Ulcer.**—This is always very chronic. It is situated usually on the outer side of the lower extremity, between the ankle and the calf, and it most frequently occurs in men about the middle period of life. The *surrounding skin* is congested, and usually presents the appearances indicative of long-continued passive hyperæmia, being frequently darkly pigmented and always indurated. The induration affects the subcutaneous areolar tissue, which is solid and brawny, and firmly fixed to the subjacent fascia, or in some cases even to the bone. There is a total loss of elasticity, both in the skin and in the subcutaneous tissue. The epidermis is often scaly and desquamates in large flakes. In many cases the cause of the mischief will be found to be varicose veins, which have given rise to chronic congestion of the skin. The *edges* of the sore are often irregular; they are hard, elevated considerably above the surface of the sore, and sink abruptly into it. The *surface* is either smooth and covered with a yellowish layer, or irregular and formed in parts of pale, feeble granulations. The *base* is hard, and firmly fixed to the subjacent fascia or bone. The *discharge* is thin and serous. There is no pain attending this ulcer, and its surface, which often attains a very large size, may usually be touched without the patient feeling it.

It is always slow to heal, for contraction forms an essential part of the healing of a sore, and the rigidity of the surrounding tissue renders this almost impossible.

Treatment.—The principle of treatment here is to soften the surrounding tissues and depress the edges of the sore by promoting absorption of chronic inflammatory products with which they are infiltrated. When this is accomplished, contraction becomes possible, and healing will progress. This is best effected by pressure.

A very efficient plan of treatment is as follows: The surface of the ulcer may first be rubbed with nitrate of silver, after which three or four layers of boric acid lint dipped in hot solution of boric acid and covered with oiled silk and cotton-wool should be applied and changed every four hours. After forty-eight hours of this treatment the sore will be perfectly clean, and may then be strapped on the plan recommended by Baynton. The best plaster for this purpose is the *emplastrum saponis*, to which some of the *emplastrum resinæ* is added to make it sufficiently adhesive; this, spread upon calico, should be cut into strips sixteen or eighteen inches in length, and about an inch and a half in width; the strips are dipped in hot carbolic or boric acid lotion and applied wet; the centre of the strip should then be laid smoothly on the side of the limb opposite to the sore, and the ends, being brought forward, are to be crossed obliquely over it. Strip after strip must be applied in this way, until the limb is covered for a distance of a couple of inches above and below the ulcer. If the sore be near the ankle, this joint should be included in the strapping. Each strip of plaster should be applied with an equal degree of pressure, which may often be considerable, and it should cover at least one-third of the preceding strip.

the cells into spindle-shaped "fibroblasts," which are arranged in lines chiefly parallel to the vessels. Fibrillation now occurs between the cells, many of which disappear, until only a few flattened ones remain amongst the bundles of fibres. At the same time. a gradual obliteration of the abundant vessels of the granulation-tissue occurs, and thus finally the surfaces of the original wound are firmly united by a thin layer of dense cicatricial fibrous tissue.

Scar-tissue differs from healthy areolar tissue in being more dense, in containing no lymphatics, and in the absence of yellow elastic fibres. It is this that gives a scar its rigidity and want of elasticity. Very old scars are said to become gradually more closely like normal fibrous tissue, and even to develop yellow elastic tissue.

Two chief views are held regarding the origin of those cells of the granulation-tissue from which the new connective-tissue cells are formed: 1st. That they are developed directly from the migrating leucocytes. 2nd. That they

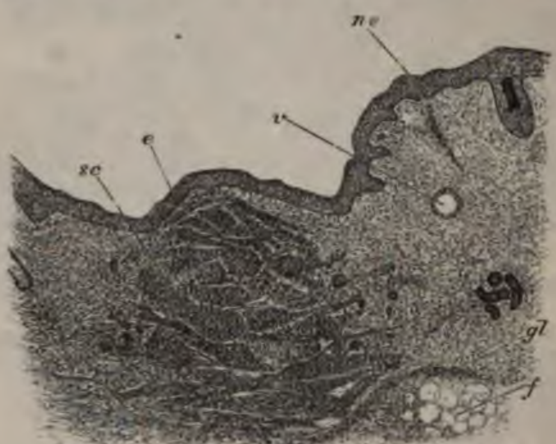

Fig. 98.—A cicatrix, three weeks old after union by the first intention; *ne*, normal epithelium; *e*, new epithelium covering the scar; *sc*, young fibrous tissue containing elongated cells parallel to the vessels; *v*, a vein; *gl*, a sweat gland; *f*, fat. The tissues on each side of the scar contain numerous leucocytes.

are formed by multiplication of the original cells of the part, which commence to divide as soon as the temporary damage done them by the injury has ceased. The difficulties in the way of the observer are great; the migration of leucocytes more or less obscures the original cells of the part, and a connective-tissue cell in process of multiplication assumes the form of a group of small cells closely resembling leucocytes.

Senftleben has shown that in the cornea a loss of substance may be obtained without inflammation, and that, under these circumstances, the corneal corpuscles may be seen to take a direct part in the process of repair. Ziegler has shown that connective-tissue can develop in a small capillary glass chamber placed beneath the skin of a dog, and he believed that the tissue was formed from migrated leucocytes which were found filling the chamber soon after its insertion. Sherrington and Ballance have experimented on the same lines as Ziegler. With full antiseptic precautions, they placed small glass chambers in the peritoneal cavity or subcutaneous tissue of rabbits and guinea-pigs, and examined the contents microscopically after periods

surrounding skin is eczematous. A paste, which differs slightly from the original formula, is prepared by heating together gelatine, 15 parts, glycerine, 30 parts, oxide of zinc, 10 parts, and water, 45 parts.

This paste, melted by heat, is thickly painted over the affected portion of the limb, and covered by a firmly applied gauze bandage, which Unna suggests should be double-headed, and crossed backwards and forwards round the part. A fresh layer of the paste may be painted over each layer of the bandage. The dressing can be left undisturbed for several days. Excellent results have followed this mode of treatment.

Another mode of treating chronic ulcers is that which was recommended by Syme, consisting in the application of a blister to the indurated edges and the surface of the sore, after which some simple dressing is used. This is often efficient, but if the sore be of any considerable size, it is possible that the patient may absorb sufficient cantharidin to cause symptoms of poisoning.

If the edges of the ulcer are so indurated that the contraction necessary for healing is impossible, Volkmann recommends that an incision should be made through the indurated tissues completely around the ulcer, and at a short distance from its margin.

Further, it must be mentioned that Thiersch's method of skin-grafting (p. 278) has been successfully applied to the treatment of callous ulcers. In cases of extensive intractable ulcers, which resist every method of treatment, amputation is occasionally required.

Irritable Ulcer.—This is met with mostly after the middle period of life. It is usually of small size, and situated behind one or other malleolus. It is frequently a consequence of varicose veins. The *surrounding skin* is usually purple, slightly indurated and sometimes pigmented; the *edges* are slightly raised, very irregular in outline, and present no signs of healing. The *surface* is but slightly below the level of the skin; it is either dark purplish-red in colour or covered with a thin slough. The *base* is but slightly indurated. The *discharge* is scanty and thin. The *pain* is the principal characteristic; it is exceedingly great, and usually worse at night, thus preventing sleep and seriously disturbing the general health. In fact, such an ulcer, if unrelieved, may bring the patient into so exhausted a condition that death may occur from some apparently slight ailment, such as an attack of bronchitis. Hilton pointed out that if the surface of the sore be carefully touched all over with the point of a probe, one or more spots will be found most acutely tender. This is due to the exposure of a nerve-ending on the surface of the sore.

In the *Treatment* of this ulcer, sedatives at bedtime are often necessary to procure rest. If opium be used, the constipation must be relieved by saline purgatives in the morning. The local treatment which I have found most successful, is to brush the surface of the sore and the surrounding parts from time to time with a strong solution of nitrate of silver (gr. x. to ℥j.), and then to keep sedative remedies, such as lead and opium lotions, applied to it. If this does not succeed, the surface of the sore may be rubbed with solid nitrate of silver until a distinct slough is formed. The treatment may be rendered painless by the previous application of a 10 per cent. solution of cocaine; the smarting, if there be any, soon ceases, and the patient will often enjoy after it the first good night's rest he has had for months. Hilton

the ulcer heal, it constantly breaks open again; or hæmorrhage may occur from a ruptured vein on its surface. Other means, which will be described in a future chapter, must then be taken for the permanent occlusion of the varicose vessels.

Ulcers on Mucous Membranes.—Various forms of ulcer occur upon mucous membranes, especially those of the throat, rectum, and genital organs. As these, however, are commonly specific, they will be described hereafter.

Ulcers of mucous membranes, when not of a specific character, present the general appearances characteristic of the cutaneous healthy, inflamed or weak varieties, and require the topical applications which have been described as suited to these conditions; though generally they will demand the free employment of caustics, or astringents, especially of the nitrate of silver.

CHAPTER VII.

THE PROCESS OF REPAIR.

Having, in the preceding chapters, described certain pathological conditions in which interference with normal nutrition and destruction of tissue form the most prominent features, we have now to give a summary of the processes by which repair takes place.

It will be most convenient to consider repair, first, as it is seen in the union of a simple wound, the surfaces of which can be brought accurately in contact with each other; and secondly, as it takes place in wounds in which the loss of substance renders this impossible, or in which the injury is such that an adherent portion of dead tissue must be cast off before any repair can take place.

Five different modes of repair of incised wounds have been described: 1. **Immediate union** or direct growing together of the opposed surfaces. 2. **Union by primary adhesion,** through the medium of a coagulable exudation from the opposed surfaces. 3. **Scabbing**, in which one of the above processes occurs beneath a scab formed of the dried discharges. 4. **By granulation**, in which granulation-tissue springs up from the bottom and sides of the wound, and eventually becomes covered by an epithelial layer; and 5. **By secondary adhesion,** in which two granulating surfaces, being placed in contact, grow together. The first two of these methods of repair are included under the term "union by the first intention," and are confined to incised and punctured wounds. The third is in reality merely an accidental condition attending union by the first intention. The last two may occur in incised wounds if union by first intention fail, and are the only means by which contused and lacerated wounds, with some rare exceptions, have been known to heal.

1. **Immediate Union.**—The direct growing together of opposite surfaces, "without any intervening substance, such as blood or lymph," was first described by James Macartney, of Dublin, in 1838. He was led to the opinion that such a process occurred by the observation of cases in which all the coarser signs of inflammation, redness, swelling, heat, and pain, with exudation, were wanting. John Hunter had believed that the bond of union in such cases was the extravasated blood. He thus described the process as he believed it to occur: "The mouths of the vessels are soon shut, either by inosculation, or their own power of contraction," "and if there should be any superfluous extravasated blood, we know that it will be afterwards absorbed. The blood being alive, this uniting medium becomes immediately a part of ourselves, and the parts not being offended by it, no irritation is produced. The red particles are absorbed, and nothing but the coagulating lymph is retained, which, being the true living bond of union, afterwards becomes vascular."

The means of observation in the time of John Hunter were inferior to those of Macartney, yet there seems little doubt that his description, erroneous as it is, contains far more truth than that of the later observer. During the last twenty or thirty years the means of studying such processes have been greatly improved ; and there can now be no doubt that such a mode of union as that described by Macartney never takes place. It is impossible to make a wound in any vascular part without damaging sufficiently the tissues to cause a coagulable exudation to take place, which, mixed with wandering cells, forms the first bond of union between the opposed surfaces. The quantity of this exudation may, however, be so small that it can be recognised only in microscopic preparations, cut, stained, and mounted, according to the modern methods; and it is not surprising, therefore, that it escaped the notice of former pathologists.

2. **Union by primary adhesion** (Paget), **primary union, union by adhesive inflammation** (Hunter), or, as it is more commonly called, **Union by the First Intention**, is that form of union which occurs without the formation of pus, and in which the accompanying inflammation is purely traumatic, being strictly limited to the tissues directly injured in the production of the wound. It is the form of union which the Surgeon aims at obtaining in all wounds unaccompanied by extensive loss of substance, or by such a degree of injury of the surface as to cause sloughing.

In order that primary union may take place, the following *conditions* are necessary: 1. That the wound be not contused or lacerated to such a degree as to cause visible sloughing of the surfaces. 2. That the interposition of any foreign bodies be carefully guarded against. 3. That the wound be closed, and its sides brought into accurate apposition. 4. That the surfaces after being brought together be kept at perfect rest. 5. That no cause of inflammation be introduced which shall tend to prolong the process beyond the period necessary for the effusion of healthy plastic exudation, or to make it spread beyond the area actually injured by the knife.

In studying union by first intention, it is essential to bear in mind the condition of the surface of a clean incised wound immediately after its infliction. The mechanical violence inflicted on the tissues by the instrument by which the wound was made, the exposure to cold air, and in the present day in many cases the application of some irritating chemical antiseptic, have all combined to damage the exposed tissues, and to lower their vitality to a degree sufficient to give rise to the process of inflammation. Here and there in individual cells or microscopic layers of tissue the damage is sufficient to cause actual death. In the whole of the immediate surface of the wound the vitality is lowered to a degree sufficient to cause stasis ; immediately beyond this we find retarded flow with exudation of liquor sanguinis and migration of the white corpuscles, and beyond this again is an area of simple vascular dilatation—the degree of damage necessarily diminishing as we recede from the parts directly touched by the cutting instrument. The thickness of the layer of tissue thus injured must necessarily vary with the sharpness of the instrument with which the wound was made, the original vitality of the tissues, the amount of violence done in cleaning the wound, the duration of exposure to cold air, and the nature of any chemical antiseptic that may be applied to it ; but in most cases of cleanly cut wounds, it is in all probability merely microscopic. This condition of lowered vitality is merely temporary ; and, if no further cause of damage

be introduced, it will pass off in from twelve to twenty-four hours, when all the phenomena of inflammation which occur as a consequence of it will subside.

This being the condition of the surfaces of the wound, the early phenomena of union by first intention are readily explained by the application of the description of the process of inflammation already given. Hæmorrhage is first arrested. In the larger vessels this is effected by artificial means to be discussed hereafter, but in the smaller it occurs spontaneously. The mechanical stimulation caused by the cutting instrument causes a contraction of the smaller arteries extending some little distance from the surface of the wound, and amounting to complete or almost complete closure, and thus the rapidity of the capillary circulation supplied by them is retarded and its force diminished. Such blood as finds its way into the wounded capillaries when it reaches the damaged area shows the phenomena of stasis. The red corpuscles adhere to each other and to the wall of the vessel, and plug its lumen, and at the most damaged part where the vessel is divided the condition passes on to definite coagulation, and a small adherent clot is formed, which closes the open mouth of the capillary. The contraction of the arteries is merely temporary, and soon passes off, giving place to dilatation ; but by the time this takes place, the clots in the divided capillaries are sufficiently firm and adherent to prevent a recurrence of the hæmorrhage. The fulness of the vessels resulting from the arterial relaxation is readily observable, and is indicated by the blush of redness, with slight swelling, always seen in the edges of a wound a short time after its infliction. This redness is not limited to the area actually injured by the knife, but extends to some distance, often one inch or more from the edge of the wound. The causes of this extensive blush of redness are, first, the stimulation of the sensory nerves consequent upon the wound, which, as we have before seen, causes vascular dilatation in the area supplied by the nerves acted on ; and, secondly, the mechanical obstruction to the circulation caused by the obliteration of the vessels divided in the wound. The blood-pressure being thus increased, while at the same time the vitality of the walls of the vessels has been lowered or suspended in the injured area, abundant effusion of coagulable exudation, with escape of a greater or less number of red corpuscles and rapid migration of the white, sets in ; and the exudation, finding a ready way by the open lymph spaces, pours out on the surface of the wound. Here it coagulates ; the fibrin entangling innumerable white corpuscles in its meshes, mixed with a variable number of red, remains adherent to the surface, while the serum, darkly stained with red corpuscles, drains away. It is seldom in the present day that an opportunity is obtained of watching the naked-eye appearances of this process, as wounds are almost invariably closed as soon as possible after their infliction; but formerly many Surgeons left wounds open, to become "glazed," as it was called, before bringing them together. In an amputation wound treated in this way the process of exudation can be watched ; drops of reddish serum accumulate here and there on the surfaces of the flaps, like beads of perspiration in profuse sweating ; these by coalescence with others, and by gradual increase, reach a certain size, and then trickle off the surface of the exposed wound, like drops of rain down a window. After the process has lasted an hour or two, the surface of the flap begins to assume a glazed appearance, the "glaze" being formed of the coagulated fibrin mixed with corpuscles as above described. This material, to which in the present day the term "*plastic*

exudation" is perhaps most conveniently applied, is spoken of also as "*coagulable lymph*," "*inflammatory lymph*," or "*lymph*." After the process has continued for some time, the serum, which was at first almost as red as pure blood, becomes almost colourless, and diminishes greatly in quantity. The two flaps, being now covered by the adhesive plastic exudation or lymph, adhere to each other readily with a certain degree of firmness if brought together, and thus a temporary union is obtained, which provides for the perfect rest and apposition necessary for the permanent growing-together of the opposed surfaces. The cessation of the exudation occurs as soon as the [illegible] The plastic exudation, just like a [illegible] completely away from [illegible] been killed by the injury [illegible] which has been discussed [illegible] union should be [illegible] time varying with [illegible] the tissues in its [illegible] washed over with [illegible] (1 in 20) or chloride [illegible] of the exudation [illegible] at the end of twenty- [illegible] impossible to obtain [illegible] continue to escape [illegible] necessarily occur in [illegible] impermeable epithelial

[illegible] removed at [illegible] presents [illegible] have not [illegible] distended [illegible] small clots. [illegible] in number [illegible] part show no [illegible] glueing [illegible] leucocytes; [illegible] concealed by [illegible] small patches of [illegible] with [illegible] the wound [illegible]

[illegible] vessels, which [illegible] ones [illegible] pouches, [illegible] grow out [illegible] form loops. [illegible] same course [illegible] completed. [illegible] of the vessel; they [illegible] the protoplasm. It [illegible] certain by what means the [illegible] each other until they meet and unite, but it is not [illegible] follows the process of a branching cell. This process of

ascularisation commences as soon as the inflammation ceases. Wywodzoff as found distinct links commencing to form in a wound in the tongue of a og forty-eight hours after the infliction of the injury. Probably in a healthy ound the process is completed by the fifth or sixth day. When fully eveloped the new vessels are very abundant, much more so than in healthy onnective-tissue. We now have, therefore, as the uniting medium, a mass of unded cells, amongst which ramify innumerable thin-walled capillaries—in ort, a thin layer of **granulation-tissue**. Granulation-tissue differs from

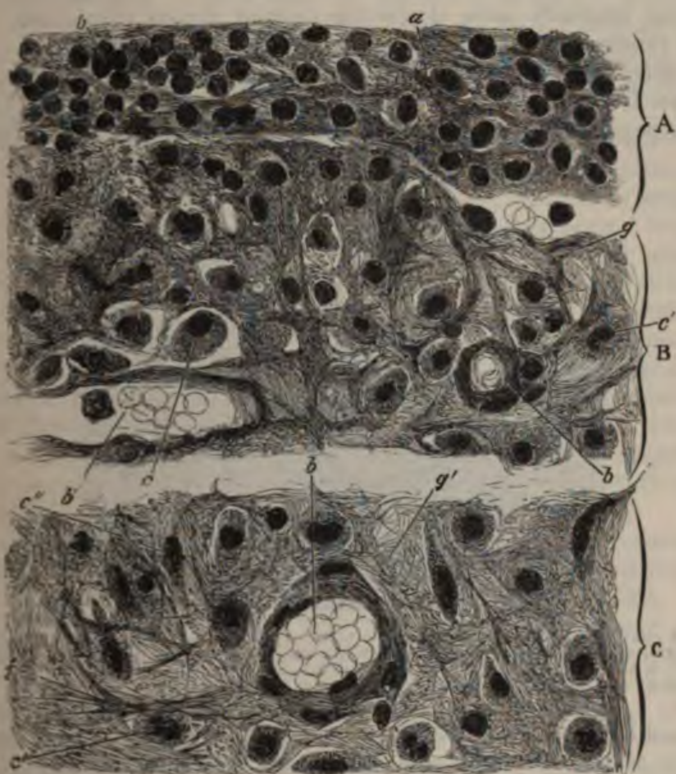

Fig. 97.—Granulation-tissue. × 800. A. Superficial layer just breaking down into pus; *a*, coagulated semi-fluid intercellular substance; *b*, pus-cells. B. Growing layer of granulation-tissue; *b*, blood-vessels, imperfectly developed; *c*, granulation-cells; *c'*, cells with nuclei dividing; *g*, homogeneous ground-substance coagulated by the hardening fluid. C. Deeper layers of granulation-tissue developing into fibrous tissue; *b*, blood-vessel; *c''*, granulation-cells lengthening out into spindle cells; *g'*, ground-substance commencing to fibrillate; *f*, rudimentary fibres.

he "plastic exudation," or "lymph," in containing vessels, and in possessing homogeneous intercellular substance, instead of the coagulated fibrin which as now disappeared. The cells which compose it are in many cases some-hat larger than white corpuscles, and some may be met with of a branched rm.

In a wound uniting by first intention, the repair of the divided epithelium kes place early by a growth of the cells of the Malpighian layer.

The rounded cells of the granulation-tissue now become gradually trans-rmed into connective-tissue cells; the first change being the elongation of

the cells into spindle-shaped "fibroblasts," which are arranged in lines chiefly parallel to the vessels. Fibrillation now occurs between the cells, many of which disappear, until only a few flattened ones remain amongst the bundles of fibres. At the same time. a gradual obliteration of the abundant vessels of the granulation-tissue occurs, and thus finally the surfaces of the original wound are firmly united by a thin layer of dense cicatricial fibrous tissue.

Scar-tissue differs from healthy areolar tissue in being more dense, in containing no lymphatics, and in the absence of yellow elastic fibres. It is this that gives a scar its rigidity and want of elasticity. Very old scars are said to become gradually more closely like normal fibrous tissue, and even to develop yellow elastic tissue.

Two chief views are held regarding the origin of those cells of the granulation-tissue from which the new connective-tissue cells are formed: 1st. That they are developed directly from the migrating leucocytes. 2nd. That they

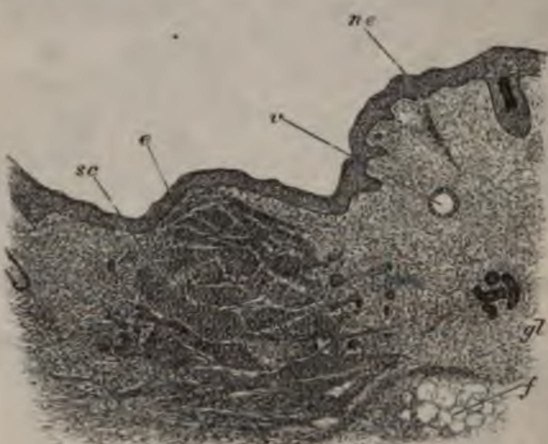

Fig. 98.—A cicatrix, three weeks old after union by the first intention; *ne*, normal epithelium; *e*, new epithelium covering the scar; *sc*, young fibrous tissue containing elongated cells parallel to the vessels; *v*, a vein; *gl*, a sweat gland; *f*, fat. The tissues on each side of the scar contain numerous leucocytes.

are formed by multiplication of the original cells of the part, which commence to divide as soon as the temporary damage done them by the injury has ceased. The difficulties in the way of the observer are great; the migration of leucocytes more or less obscures the original cells of the part, and a connective-tissue cell in process of multiplication assumes the form of a group of small cells closely resembling leucocytes.

Senftleben has shown that in the cornea a loss of substance may be obtained without inflammation, and that, under these circumstances, the corneal corpuscles may be seen to take a direct part in the process of repair. Ziegler has shown that connective-tissue can develop in a small capillary glass chamber placed beneath the skin of a dog, and he believed that the tissue was formed from migrated leucocytes which were found filling the ber soon after its insertion. Sherrington and Ballance have experimented e same lines as Ziegler. With full antiseptic precautions, they placed glass chambers in the peritoneal cavity or subcutaneous tissue of rabbits guinea-pigs, and examined the contents microscopically after periods

varying from four hours to eighteen days. These observers concluded that the film of connective-tissue which formed in the chamber was derived, not from the leucocytes, but from larger "plasma cells," which were also present, and were presumably derived from the fixed tissue cells. The results of experiment, together with a study of the mode of repair of epithelium, may thus be said to support the view that the new tissue formed in the process of repair is derived from the original connective-tissue of the damaged parts. The exact mode of origin of the fibres of the scar-tissue is another disputed point: it is uncertain whether they are formed by a change in the protoplasm of the cells or by a process of fibrillation in the intercellular ground substance. Sherrington and Ballance were unable to satisfy themselves on this point, but inclined to the belief that the fibres were formed in an intercellular substance secreted by the cells.

The **time occupied in the process of repair** is not accurately defined. We have already seen that the formation of the "plastic exudation," or "lymph," commences immediately after the injury, and under favourable circumstances is finished by the end of the first twenty-four hours. According to Billroth, new vessels can be seen commencing to form within forty-eight hours, and by the end of a week a complete communication is established between the capillaries on each side of the wound. Early in the second week the cells have lengthened out, and the development of fibrous tissue has commenced; and by the end of the second week the superabundant vessels have been partly obliterated, and the new tissue has assumed a considerable degree of firmness. The final obliteration of the vessels in the cicatricial tissue is a slow process, lasting many months. Until this is completed the scar remains redder than the surrounding skin, though afterwards it becomes opaque and white.

It is evident that these changes can be seen on microscopic examination only in those wounds in which the surfaces have been separated from each other by an appreciable layer of plastic exudation or coagulated blood. When the apposition of the surfaces has been more perfect, the layer of uniting material may be so thin as to be scarcely recognisable, and four days after the infliction of the wound it may be almost impossible to detect any bond of union, the line of the incision being marked only by the presence of a few wandering cells and some traces of unabsorbed red corpuscles. That true union, however, in such a case has not definitely taken place at this time is shown by the care which is necessary, in preserving the specimen for microscopic examination, to prevent the surfaces from separating from each other.

We have thus traced the development of a scar, and shown that in its formation new blood-vessels, epithelium, and fibrous tissue are developed, and as a rule these structures alone form the bond of union after division of the soft parts. In wounds of cartilage, muscle and central nervous tissue, no regeneration of the original tissues takes place, the scar being composed solely of fibrous tissue. Large vessels when completely divided are obliterated and converted into a fibrous cord as far as the nearest collateral branch. As we shall see hereafter, bone is repaired by bone, and under favourable circumstances large nerves are completely united by normal nerve-tissue. In large scars, however, the development of new nervous tissue is very imperfect, if it occurs at all. Little is known of the formation of lymphatics in old scars; but injections show that they are wanting in granulation-tissue and young scars.

the cells into spindle-shaped "fibroblasts," which are arranged in lines chiefly parallel to the vessels. Fibrillation now occurs between the cells, many of which disappear, until only a few flattened ones remain amongst the bundles of fibres. At the same time, a gradual obliteration of the abundant vessels of the granulation-tissue occurs, and thus finally the surfaces of the original wound are firmly united by a thin layer of dense cicatricial fibrous tissue.

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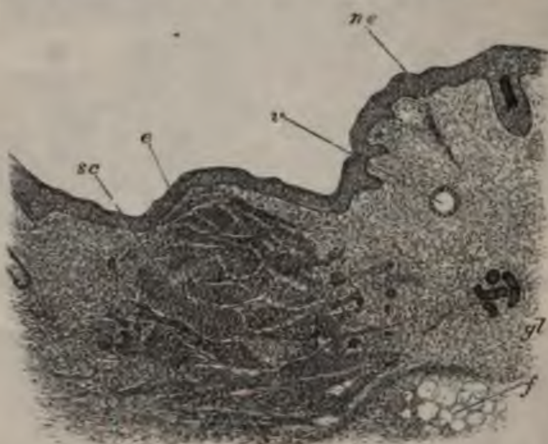

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The process of union by first intention is disturbed by any cause which prolongs the inflammation, or makes it assume a spreading or infective character. Under these circumstances the transudation of liquor sanguinis and the migration of the white corpuscles will continue, and instead of the thin layer of dry firm plastic exudation, composed merely of living corpuscles entangled in the meshes of the coagulated fibrin, there will be a soft exudation, excessive in quantity, the more superficial layers of which will soften and break down into pus, a fluid layer thus being interposed between the surfaces of the wound, effectually preventing primary union.

Amongst the causes which lead to persistence of inflammation in a wound and consequent suppuration, the following may be mentioned as the most common :—

1. The nature of the injury ; a blunt or jagged weapon may so damage the tissues as to cause actual death of a layer of some thickness, which must be separated by a process of ulceration (see p. 272).

2. The tissues themselves may be feeble either from general or from local causes, and consequently possess a diminished power of resisting injury and of rallying from its effects.

3. The raw surfaces may be constantly rubbed against each other if the wounded part be not kept at perfect rest, and the mechanical irritation from this cause is quite sufficient to maintain the process of inflammation.

4. If proper provision be not made for the escape of the serum that necessarily flows from the freshly wounded surface, the cavity of the wound becomes distended by it, and not only are the surfaces separated from each other, but they are exposed to the irritation of *tension*. While this is acting the inflammatory process cannot subside, but the exudation will continue and intensify the evil, the cavity of the wound coming to resemble that of an acute abscess. Tension from tight stitches causes a similar persistence of the inflammatory process.

5. If in such an undrained wound the causes of decomposition are present, putrefaction of the serous fluid speedily sets in, and the irritating products of decomposition, pent up as they are in contact with the raw surface at some degree of pressure, soak away into the lymph-spaces of the surrounding tissues, and thus cause a spreading inflammation which may extend to a considerable distance beyond the area actually injured by the instrument which inflicted the wound. The firm plastic exudation that is left uniting the surfaces of a well-drained wound being composed almost entirely of living cells is not liable to putrefaction, and any of the ordinary micro-organisms which may come in contact with it are powerless to produce any evil effect. It need hardly be pointed out that unless decomposable matter, either in the form of excessive blood-clot or pent-up serum, is present in the wound, no decomposition will take place.

6. The persistence of the inflammation may be due to the presence of a foreign body in the wound. A foreign body may act either from being itself irritating, mechanically or chemically, or from being porous in character, and thus absorbing serum, which afterwards decomposes. On the other hand, smooth non-absorbent bodies, such as metals, or soft absorbent substances, as unwaxed silk, under successful antiseptic treatment may become enclosed in a healing wound without causing the formation of pus.

7. Lastly, union by first intention is necessarily prevented by the inocula-

may be brought about by stimulation of the vagus. If that nerve be exposed in an animal, and stimulated by an electric current of moderate strength, the heart ceases to beat, and remains with all its cavities flaccid, as long as the stimulation is continued. If the current be very feeble, the action of the heart will recommence after a short interval, even if the passage of the current be continued; if very powerful, the inhibition will continue after the current has been removed. A current of sufficient strength may permanently arrest the heart's action. These effects may be brought about by reflex as well as by direct stimulation of the vagus. Thus, if a frog's foot be suddenly crushed, the heart ceases to beat for a moment, after which it acts for a short time more forcibly than before. This reflex inhibition is still more marked if the terminal branches of the vagus be directly stimulated. In dogs and rabbits sudden death has frequently been observed as a consequence of injury done to the larynx or trachea during an experiment.

These observations may be applied directly to man with the addition that in the human subject mental emotions frequently form the afferent impulse. Sudden death from shock has been recorded as the result of slight blows on the epigastrium, or of drinking ice-cold water, in both which cases a sudden stimulus is applied to the terminal branches of the pneumogastric nerve; and some sudden deaths under chloroform have been supposed to be due to reflex inhibition of the heart from the stimulation of the nerves of the trachea by too strong a dose of the anæsthetic.

2. **Shock with General Exhaustion of the Nervous Centres, Collapse or Torpid Shock,** is the form commonly met with after severe injuries and operations. No doubt at the moment of infliction of the injury cardiac inhibition takes place as above described, but this cannot explain all the phenomena of shock as usually met with in surgical practice. In fact, in extreme shock, the cardio-inhibitory centre seems to be exhausted, and the pulse, though feeble, is more rapid than natural.

The **symptoms** of shock vary according to the severity of the injury, the importance of the part injured, and the nervous susceptibility of the sufferer.

When the injury is not severe, does not implicate important parts, or occurs in an individual of strong nerve, the symptoms are slight and passing. But if the injury be very severe, if it affect a vital part, or if the sufferer be of excessive nervous susceptibility, the phenomena are much more marked.

In such cases, the sufferer becomes pale, cold, faint, and trembling; the pulse is small and fluttering; the respiration is shallow and feeble; there is great mental depression, the disturbed state of mind revealing itself in the countenance, and in feebleness or incoherence of speech and thought; the surface becomes covered with a cold sweat; the sphincters may be relaxed. In severe shock, the temperature commonly falls to about 97° Fahr. in the adult. In the young, the fall is less; in the aged, it is greater. I have several times found it below 95° Fahr. in the mouth and axilla, and Wagstaffe has met with cases in which recovery followed a fall of temperature amounting to four degrees. In fatal cases a fall of six degrees has been observed. These symptoms commonly set in immediately on the receipt of the injury. In some cases, however, there is an interval of time between the infliction of the injury and the appearance of the shock; this is more particularly the case in persons

there is always some source of irritation present which continues to act for a considerable time after the injury, and thus gives rise to a prolongation of the inflammatory process with the formation of pus. Thus, in a simple open wound with loss of substance, the raw surface is exposed to the influence of air, to the mechanical irritation of the dressings, and to the chemical irritation of antiseptic solutions in some cases and decomposing discharges in others. In poisoned wounds the specific virus with which they are infected maintains the inflammatory process. In cases of contused and lacerated wounds, or in burns and scalds, the dead tissue serves as a source of prolonged irritation until it is separated by ulceration and thrown off.

The process of union by the second intention is followed most easily in the

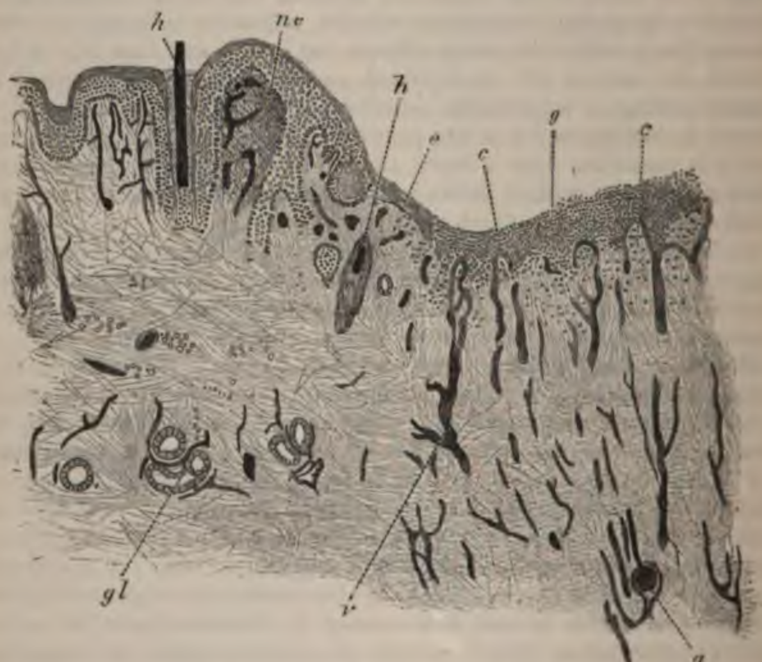

Fig. 99.—Granulating sore, injected. *h*, a hair; *ne*, margin of sore; *e*, new epithelium at the edge of the sore; *c*, a newly-formed vascular loop; *g*, granulation-tissue; *a*, an artery; *v*, a small vein; *gl*, sweat-gland.

case of a simple wound with loss of substance so extensive as to render the approximation of the surfaces impossible. The hæmorrhage in such a wound is arrested in the same way as has already been described in treating of union by the first intention, and the same process of exudation takes place. The plasma coagulates on the raw surface, the serum drains away, and the fibrin remains behind entangling the migrating leucocytes in its meshes. In union by first intention, as we have seen, the exudation ceases in a few hours, as the ...es, not having been injured to such an extent as to destroy their vitality being protected from every source of irritation, speedily return to their ...l state. In such a wound as we are considering, however, the raw ... must necessarily be in contact with some foreign material, and is thus

exposed to a persistent source of irritation in consequence of which the exudation continues; the migrating cells accumulate on the surface, forming a layer of considerable thickness, and infiltrate the tissues beneath, destroying and taking the place of the superficial parts which have suffered most severely from the injury and the subsequent sources of irritation. The superficial cells of the layer thus formed being exposed necessarily to injurious influences, such as the contact of foreign bodies, the irritation of antiseptic dressings, or of decomposing discharges, &c., perish, become granular, lose their adhesion to each other and float away as pus-cells in the serous discharge. In the pus that is thus formed on the surface of the sore, some freshly migrated white corpuscles still manifesting the characteristic amœboid movements will always be found. While this process of pus-formation is taking place on the surface, development of new vessels, by the process already described under union by first intention, is taking place in the layers beneath, and at the same time there is an active cell-growth which more than compensates for any loss that may be taking place from the surface in the formation of pus, and the loss of substance which resulted from the original injury is gradually repaired. We have thus developed an actively growing layer of granulation-tissue, that is to say, of a tissue composed of small round cells adhering to each other by a homogeneous intercellular substance, and traversed by an abundant system of thin-walled capillary vessels. In a superficial granulating sore the vessels form loops the convex sides of which are directed towards the surface (Fig. 99). The same differences of opinion exist as to the origin of the cells which appear in the process of healing by second intention that have already been pointed out as existing with regard to the same process in union by the first intention. In whatever way, however, the cells are formed, this much is certain, that "granulation-tissue" is a true tissue, resembling embryonic tissue in its power of growth, by which it fills up the gap left by the loss of substance or formed by the gaping of the surfaces of a wound in which union by first intention has failed. Like any other tissue, "granulation-tissue" is capable of suffering from inflammation if exposed to injurious influences. If removed from every source of irritation, the circulation is as active through the new vessels as it is in those of the original tissues, transudation is not in excess of the requirements of nutrition, and few, if any, of the corpuscular elements of the blood escape through the vascular walls. The growth takes place by the division of the cells of the granulation-tissue, and not by the addition of migrating corpuscles from the vessels. If the tissue be exposed to injurious influences which lower its vitality, exudation takes place, making the granulations swollen, soft or even œdematous, and multitudes of migrating cells find their way to the surface and float away with the serum as pus, mixed with the superficial granulation-cells which have perished and left their adhesion to each other. Thus, when on a raw surface a healthy layer of granulation-tissue is formed, it is theoretically possible that the surface may discharge no pus, only a small quantity of serous fluid escaping owing to the want of an impermeable epithelial covering. In order that this may occur, the delicate cells of which its surface is composed must be protected from every possible source of irritation, whether physical, mechanical or chemical. Such a condition it is practically scarcely possible to obtain, but experience of modern methods of dressing has shown that by proper treatment the quantity of pus and the number of corpuscles it contains may be greatly

there is always some source of irri[illegible] thick creamy pus is no longer regarded considerable time after the injury, [illegible] inflammatory process with the [illegible] formed by healthy growth without inflammation wound with loss of substance, [illegible] and firmness, being capable of withstanding air, to the mechanical irritation [illegible] without breaking down. A perfectly of antiseptic solutions in some [illegible] quite a severe blow with the finger without In poisoned wounds the spe[illegible] other hand, when it is swollen by inflammatory the inflammatory process. [illegible] violence suffices to disintegrate its structure. burns and scalds, the dead [illegible] as a rule, that granulation-tissue is soft in direct until it is separated by [illegible] irritation to which it is exposed; and as the repair

The process of union [illegible] by solution of continuity, whether subcutaneous [illegible] through the medium of granulation-tissue, the [illegible] mind is very great.

[illegible] of granulation-tissue into the fibrous tissue of [illegible] from that already described under union by the [illegible] the second intention, however, the effects of the [illegible] the process are proportionately more marked as [illegible] granulation-tissue are greater. The amount of the [illegible] size of the sore and the looseness of the structures [illegible] Thus the scar left by a sore the size of a half-crown on [illegible] little more than a quarter of an inch in diameter, while [illegible] probably be about the size of a sixpence, and on the thigh, [illegible] skin to spare, it would be about the diameter of a shilling. [illegible] produced by the healing of extensive granulating [illegible] after burns and scalds. This process of contraction is an [illegible] healing, and if from any cause, such as want of skin or [illegible] contraction is not possible, the sore ceases to heal.

[illegible] over of the surface of the sore with new epithelium is accom[illegible] of multiplication of the cells at the margin of the sore. New [illegible] from pre-existing epithelium only, and there is no reason [illegible] believe that the granulation-cells can develop into epithelial

[illegible] in which a slough has to be separated before repair can commence, [illegible] accomplished by the process described under Ulceration (see p. 271).

[illegible] clinical phenomena that attend the process above described are as [illegible] Supposing the case to be one of simple loss of substance produced by [illegible] cutting instrument, the raw surface, after bleeding has ceased, continues [illegible] discharge a quantity of serum, at first tinged with blood, but gradually [illegible] becoming colourless; at the same time a glaze is seen to form, due to the [illegible] exudation adhering to the surface of the wound. The healthy skin around the wound becomes redder than natural, the blush gradually fading [illegible] we recede from the wound. Little further change is observed in the [illegible] surface of the wound till the end of the second or third day, by which time [illegible] is distinctly redder; by the third or fourth day, florid red spots begin to [illegible] here and there, and the discharge becomes distinctly purulent. Gradually the red spots coalesce, and the surface becomes covered by the fifth or sixth day with a uniform, highly vascular layer of granulation-tissue. The surface is no longer smooth, the new cells being formed around the vascular [illegible] little heaps, which give it the granular appearance which has [illegible] for the new tissue the name of "granulation-tissue."

A typically healthy granulating surface presents the following characteristic features. The separate granulations are about the size of split mustard-seeds; they are uniform in size, and of a florid red colour; they will stand a smart blow without bleeding, and, being devoid of nerves, are perfectly free from sensibility. The surface of the sore is very slightly depressed below that of the surrounding skin. The base of the sore is soft. The edges shelve gradually down into the surface, and, if healing is taking place, the new growing epithelium can be seen spreading over the surface of the granulations and giving rise to three zones of different colour. Most internally is a dark red line, darker than the neighbouring granulations. This is due to some slightly increased vascularity beneath the growing epithelium, and to the presence of a very thin layer of perfectly transparent new epithelium-cells covering the granulation-tissue. That this is so can be shown by carefully drying the surface and watching it for a few seconds: the uncovered granulations become moist again almost immediately, while the red line remains dry. Outside the red line is a blue line, resulting from the presence of a thicker layer of epithelium, seen through which the red granulations assume a bluish tint. Outside this again is an opaque white line, in which the new epithelium has been formed in sufficient quantity to be opaque when sodden by the discharges. The discharge varies with the mode of dressing. If some slightly irritant lotion or dressing be applied, thick creamy pus is poured out from the surface; if some non-irritating dressing be applied, thin serous fluid flows away, made more or less turbid by the presence of a few pus-cells. A granulating sore may present a perfectly healthy appearance with both conditions of discharge, but it will usually be found that the red line of new growing epithelium is much wider in those cases in which the dressing is least irritating, as under other conditions many of the young epithelium-cells perish and mingle with the pus-cells in the discharge.

The constitutional symptoms that attend union by the second intention will vary much. The separation of a slough will in all cases be attended with some febrile disturbance if the dead tissue be allowed to putrefy; by antiseptic treatment, however, this may be entirely prevented, and union by the second intention may be accompanied by as little constitutional disturbance as that by the first intention. In cases in which no antiseptic precautions are observed, the febrile disturbance due to the absorption of the products of putrefaction commences on the second day after the injury, and reaches its maximum by the third or fourth. By this time the lymph-spaces are becoming filled with the plastic exudation, and absorption is consequently limited. When the slough is separated and the granulation surface is formed—that is to say, by about the sixth to the tenth day—the fever disappears, as healthy granulations, being devoid of lymphatics, form a barrier to the absorption of septic matter unless it is pent up at some degree of pressure.

The changes taking place in a cicatrix do not cease with its formation. In most cases the contraction of the scar does not attain its maximum until long after the completion of superficial cicatrisation, and this may occasion great puckering and deformity. The amount of contraction of a scar is dependent solely on the size of the original raw surface and on the laxity of the tissue in which it is seated. There is no evidence to justify the assertion so commonly made, that the scars resulting from sores produced by acid caustics and burns contract more than those following the action of alkaline caustics

or superficial wounds. A circular scar round a tubular organ or excretory duct, as in the intestine, œsophagus, or urethra, leads to narrowing or stricture of the canal, and many of the worst œsophageal strictures result from the accidental swallowing of caustic alkaline fluids. These strictures in most cases gradually become narrower as time goes on, the process of contraction continuing long after the sore has healed.

Further changes are wrought by time in the texture of a cicatrix. When a scar is first formed, it is thin, reddish, or bluish and shining, being composed of imperfectly developed fibrous tissue, covered by a thin epidermic layer. As it becomes older, it assumes a dead-white colour, and becomes depressed, and gradually, but slowly, many years being perhaps required for the change, it "wears out;" that is to say, its structure more closely resembles that of the texture of the part in which it is seated. It never, however, becomes developed into true skin, as neither sebaceous nor sudoriparous glands nor hair form in it.

Coincidently with these changes, the scar loosens its deep attachments, so that it can be moved more freely upon subjacent parts. It is a long time before the scar attains the vitality of the older structures, if ever it do so completely; and the larger it is, the less its power will usually be. Under the influence of scurvy or syphilis, an old scar is apt to open up again; so also, if a fresh ulcer be formed on the old cicatrix, it will take a longer time to heal than the original one.

5. **Union by Secondary Adhesion.**—It not unfrequently happens that, although granulations spring up over the sides of a wound, union between the opposed surfaces does not take place. We endeavour to accomplish this by bringing the granulating sides together, and retaining them in that position, when they will cohere; this constitutes union by "*Secondary Adhesion.*" In some amputations, and in many plastic operations, cases of hare-lip, cleft-palate, &c., union is occasionally brought about in this manner.

The conditions necessary for this mode of union are, 1st, that the granulating surfaces be perfectly healthy; 2nd, that they be smooth, so that they can be brought evenly into apposition without leaving cavities between them in which pus may accumulate; and 3rd, that after they are brought together they shall be kept at perfect rest.

Circumstances affecting the Healing Process.—In concluding this general description of the process of union of wounds, it will, perhaps, be well to recall briefly some of the conditions essential to rapid and certain healing. In the first place, two conditions are absolutely essential: perfect rest and perfect drainage. No wound can heal by the first intention if its surfaces are frequently rubbed against each other, either by the movements of the injured part or by the clumsiness of the Surgeon in changing the dressings; nor can early union occur if the surfaces are separated from each other by pent-up serous discharge. The third great source of irritation to which wounds are exposed is the presence of decomposing matter between their surfaces. In order that this should occur it is hardly necessary to say that there must be some dead matter there to decompose; living tissues do not putrefy, and amongst living tissues must be reckoned the plastic exudation that glazes a wound, and forms the preliminary bond of union. On the other hand, the serous discharge which is poured out in the first twenty-four hours is decomposable. A perfectly-drained wound with no foreign body in it

blood-clot possesses powerful pyrogenic properties which they attribute to the fibrin-ferment, which it always contains in considerable quantities in a free state. If the ferment be injected in large quantity, other symptoms are developed resembling septicæmia, and often associated with coagulation of blood in the heart or cardiac thrombosis. Clinical experience seems to confirm this view. Large subcutaneous extravasations of blood are usually accompanied by very marked febrile disturbance, and the same has been observed in the transfusion of defibrinated blood. In a large wound, when the drainage is imperfect and an accumulation of aseptic serous discharge takes place, very distinct elevation of temperature is the common result. It is very possible that the application of strong antiseptic fluids to the raw surface of a wound, by increasing the exudation during the first few hours, may slightly add to the fever in some cases, and want of rest or the accumulation of blood-clot in the cavity of a wound may produce a similar effect.

Septic Traumatic Fever is due to the absorption of the chemical products of putrefaction from the surface of a wound. Until granulations, which offer an efficient barrier to the passage of septic products, have sprung up, the raw surface left by a wound absorbs these with the greatest readiness. It has been shown by experiment that salts, such as potassium ferrocyanide, are taken up with great rapidity, and can be detected in the urine within a very short time after their application to a raw surface; the rapidity of absorption is scarcely if at all less from a surface which has been cauterised with a hot iron, but the application of a strong solution of chloride of zinc materially retards, or even prevents, the entrance of the salts into the circulation. The presence of septic matter in a wound, in addition to the constitutional disturbance it directly gives rise to, always causes more or less local inflammation, the products of which no doubt aid in setting up the fever. The severity of septic traumatic fever is proportional to the dose of the chemical products of putrefaction which enters the circulation; consequently it will vary directly with the amount of septic matter present and the size of the wound. If the decomposing matter be pent up at some degree of pressure, the rapidity of absorption will be increased. Should the dose be sufficient, the patient may die rapidly from the direct toxic effects of the chemical products of putrefaction, a condition which will be described as one of the forms of septicæmia. Between this and septic traumatic fever the difference is only one of degree. Guided by these facts, the prevention of septic traumatic fever can in most cases be successfully accomplished: first, by perfect drainage of the wound, by which the amount of decomposable matter is reduced to a minimum; and secondly, by the employment of those modes of dressing which will prevent the decomposition of such liquid exudation as may unavoidably remain in contact with the raw surface.

Should septic fever occur it commences on the second day, and reaches its highest point by the third or fourth. At this time the temperature reaches 103° F. or 104° F., or even higher. It remains at about the same height, with the usual evening rise and morning fall, till the ninth or tenth day, by which time granulations have sprung up throughout the wound, and the absorption of septic matter ceases more or less completely according to the perfection of the drainage. During the fever the pulse is generally frequent in proportion to the temperature, the disturbance of appetite is great, there is often delirium, especially at night, and rapid loss of flesh. The decline of the

fever, or defervescence, is sometimes rapid, occurring in a period varying from twenty-four to thirty-six hours; but should the wound be one in which perfect drainage is difficult, as in a compound fracture, decomposing pus may be still pent up in parts of the cavity at some degree of pressure, and under these circumstances the decline of the fever will be much delayed, and the symptoms may gradually merge into those of "hectic," attended with the marked evening exacerbations, the profuse sweats, and progressive loss of strength.

Traumatic Delirium presents itself as two distinct types, the one *inflammatory*, the other *nervous*.

In **Inflammatory Traumatic Delirium** there is a quick and bounding pulse, hot skin and head, flushed cheeks, glistening eyes, much thirst, and high fever; in fact, this form is merely the delirium which accompanies the fever consequent upon the absorption of the products of septic or infective inflammation from the wound. Occasionally the patient is violent, tossing himself about the bed, and moving the injured part, insensible to or regardless of pain. More often there is mere wandering of mind; and in mild cases the patient will answer questions rationally. The symptoms are most marked at night, and diminish when the morning fall of temperature commences; they usually set in on the third day, and are most marked by the third or fourth, which, as before stated, is the time at which septic traumatic fever reaches its highest point. The *Treatment* of this form is best carried out by the application of ice to the head; the bowels must be kept well open, and the diet must be light but nutritious. The use of stimulants must be determined by the state of the pulse; when this is very rapid, alcohol often diminishes the delirium and produces sleep; when it is very full and bounding and the patient is young, bleeding from the arm may occasionally be resorted to, but this is seldom required. The patient must be carefully watched, as there is often a constant desire to get out of bed. At the same time that these measures are adopted, local means must not be neglected to subdue the inflammation, and remove any septic matter or pent-up discharges which may be giving rise to the febrile disturbance.

Nervous Traumatic Delirium usually occurs in persons whose constitutions have been broken by habitual excess in drinking; and in fact, it is in most cases, if not always, an attack of ordinary delirium tremens, induced by the shock of the accident. Most commonly the earliest sign is want of sleep, with a restless nervous manner; in some rare cases it is preceded by a fit of an epileptiform character. The pulse becomes quick, small, and irritable; the surface is cool, and usually covered with a clammy offensive perspiration; in cases uncomplicated by an open wound there is usually no elevation of temperature; should there be fever, the gravity of the case is greatly increased. The tongue is white and furred, and there is usually tremor both of it and of the hands. The delirium is of a muttering, suspecting character; the patient is often harassed by spectral illusions, but will answer questions rationally. Traumatic delirium tremens is sometimes very rapidly fatal. I have known it to destroy life in cases of simple fracture in less than twelve hours. In other cases, death takes place after some days from exhaustion; and the fatal termination is occasionally sudden.

A form of *maniacal delirium* is occasionally met with after operations in persons of great nervous susceptibility, who have been exposed to severe mental strain before the operation. It has been not unfrequently observed after

removal of the breast, especially in those cases in which the patient has long concealed her disease, and finally with a great mental effort submitted to the operation.

In the *Treatment* of nervous traumatic delirium, the essential points are to induce sleep and to keep up the patient's strength. The foul tongue and breath are sufficient indications of the necessity of administering a brisk purgative at the commencement of the treatment; in many cases no sedatives will have any effect till the purge has acted. The motions brought away by the medicine are usually excessively foul. The best sedatives are bromide of potassium, morphia, and hyoscyamus. The bromide may be given in twenty-grain doses, repeated every two or three hours. Morphia may be given in quarter-grain doses, repeated at intervals of four hours, till one grain is reached, or till sleep is induced. The effect of the drug must be carefully watched. It is always better to administer it hypodermically when possible, as in some cases it seems to be imperfectly absorbed from the disordered stomach. Hyoscyamus may be administered in half-drachm doses of the tincture, but it is less effectual than morphia. Both morphia and hyoscyamus may be given in combination with the bromide. Hydrate of chloral has also frequently been used; but it is not so safe a drug as those just mentioned, as an excessive dose may kill the patient suddenly. Sulphonal sometimes succeeds in inducing sleep when other drugs have failed. The Surgeon must use his judgment as to the extent to which the sedatives may be pushed. If they fail to act, it is wiser to discontinue them than to run the risk of giving a poisonous dose. Food is even of more importance than sedatives; so long as the patient can take an abundant supply of good liquid nourishment there is hope of his recovery. Solids must be avoided, as the stomach is never in a state to digest them. If there be much depression, it will usually be advisable to administer some stimulant, that to which the patient has habituated himself being the best. It is sometimes convenient to mix the sedative with the stimulant. If the patient be strong, there is no danger in cutting off all stimulants, even in the case of a confirmed drunkard. After sleep has been induced, the quantity of sedatives must be lessened; but it will often be found necessary to continue them for some time, as there will be a tendency to recurrence of the delirium at night.

The patient should, if possible, be put in a room by himself, and watched by a single attendant. If he is violent, he should be at once put in a strait-waistcoat, as it excites him much less to struggle with an inanimate object than with a couple of men. When the strait-waistcoat is firmly applied, the attendant should keep out of sight as much as possible while watching him. If the injury is a broken bone in a limb, the injured part must be fixed firmly in splints well padded with cotton-wool and swung from a cradle; it must on no account be fixed to the bed, for every movement of the patient would then grind the bones together, and perhaps render a simple fracture compound. The patient seems absolutely insensible to the pain caused by such movements.

These two forms of traumatic delirium, the inflammatory and the nervous, are often found more or less conjoined, and in such cases the prognosis is always grave, as exhaustion speedily sets in; stimulants and abundant fluid nourishment must then be freely administered.

of great mental fortitude, or whose minds are actively engaged at the moment of the receipt of an injury.

The condition of shock may gradually increase, the pulse becoming more feeble, the respiration more shallow, and the consciousness more impaired, till death takes place. Fortunately, however, this termination is comparatively infrequent, and occurs only in the most severe injuries. As a rule, after a longer or shorter period, varying according to the severity and seat of the injury and the nervous susceptibility of the patient, the symptoms abate and *reaction* sets in. The surface becomes warmer, the pulse more forcible, the respiration fuller, consciousness becomes more perfect, and colour returns to the face. Vomiting is not an uncommon symptom during the early periods of reaction, and is probably due to some degree of hyperæmia of the brain following the cerebral anæmia which forms a prominent feature of extreme shock. It is not uncommon to find the temperature very slightly elevated during the period of reaction.

The recovery from shock is usually complete. In cases, however, in which it has arisen from violent concussion of the whole system, as in a railway accident, various secondary phenomena may present themselves. These are probably due to actual lesion of the nervous centres, and are fully described in the chapter on Injuries of the Spine.

Pathology of Shock.—There are no characteristic *post-mortem* appearances. The heart, rarely contracted, is more often found full of blood, especially the right side, and the whole venous system is somewhat gorged, unless the patient has lost much blood from the accident. The blood was said by Hunter to remain fluid in some cases, but this is certainly very rare. Rigor mortis is usually well marked. The lungs are engorged, the abdominal viscera congested, but the brain is pale and anæmic.

It is evident that the symptoms above described are more than can be accounted for by any simple theory of cardiac inhibition. The most probable explanation of shock is that it is due to a general exhaustion of the nervous centres consequent upon an extremely violent afferent impulse. In cases of injury this impulse is partly physical, due to the division or crushing of the nerves of the injured part, and partly mental, arising from the fear and sense of suffering caused by the accident. In operations performed under the influence of an anæsthetic, the latter cause would be absent; but as the conductivity of the nerves and the functional activity of the medulla and great centres at the base of the brain are unimpaired during anæsthesia, shock is not avoided, though it is certainly diminished in intensity. The exhaustion of the nervous centres in shock is shown by the general state of muscular relaxation, the loss of tone throughout the vascular system, the feeble action of the heart, and the state of semi-unconsciousness into which the patient is thrown. The general relaxation of the vessels throughout the body, thus occurring simultaneously with an extremely feeble action of the heart, leads to an accumulation of blood, with partial stagnation in those parts of the vascular system which are most dilatable. This is especially marked in the veins of the abdominal cavity. The lungs are also frequently gorged with blood. The abstraction of so large a portion of the blood from the circulation causes anæmia of other parts, and it is thus that the pallor of the skin and the anæmia of the brain may be explained. It has been assumed that the vaso-motor paralysis is most marked in, or even limited to, the parts supplied

by the splanchnic nerves, but there seems to be nothing to justify such an assumption. General vaso-motor paresis combined with feeble action of the heart would necessarily cause accumulation of blood in the large veins of the abdominal viscera, and probably also in those of the flaccid muscles. The wide diffusion of the exhausting effects of an intense afferent impulse is also in accordance with the results of experiment. A very feeble stimulus applied to a nervous centre acts on that centre only, but more powerful stimulation is always found to diffuse itself widely to neighbouring parts. Thus, if a cortical motor centre in the brain be exposed and stimulated by a very feeble electric current, movement is produced in the limited group of muscles corresponding to that centre, whilst a stronger current causes a general convulsion affecting the whole body.

The anæmia of the nervous centres aggravates the shock and delays the recovery of the exhausted centres. In fatal cases, it is probably the immediate cause of death. It is necessarily increased by loss of blood.

Causes.—The most serious forms of shock are those that arise from gun-shot wounds and railway collisions. The severe and deeply penetrating character of the injuries in the one case, and the suddenness of their occurrence, with the terror inspired by them, in the other, explain the severity of their effects on the nervous system. Shock is partly due to *mental*, partly to *physical* causes. Its severity and continuance are thus materially influenced by the mental condition of the patient, and by the degree and nature of his injury.

In persons of a very timid character, or of great nervous susceptibility, and in those who are liable to the occurrence of syncope—more especially in females—a very trivial injury may produce an extreme degree of shock; indeed, the mere apprehension of injury may, without the occurrence of any physical lesion, give rise to all the phenomena of shock. Thus, Verneuil mentions a case in which sudden death occurred whilst the incisión for an intended tracheotomy was being marked with the back of the knife. The state of mind at the time of the receipt of the injury influences its effects on the nervous system. If the patient be anxiously watching for the infliction of a wound, as waiting for the first incision in a surgical operation, all the attention is concentrated upon the coming pain; it is severely felt, and the consequent shock is great. If, on the other hand, the attention be diverted, and the mind in a state of intense excitement, as in the hour of battle, a severe injury may be inflicted, and the patient be unconscious of it, feeling no pain, and experiencing no shock, perhaps not knowing that he is wounded till he sees his own blood. The severity or shock is in a great measure proportionate to the degree of pain attendant upon an injury, and, as sensibility to pain varies greatly in different individuals, so will the attendant shock be greater in some than in others. The sensibility of individuals varies much, and is greatly dependent on occupation, sex, and temperament. Men who live hardy outdoor lives are less sensitive to pain than those who follow occupations of an opposite kind. The higher man rises in the scale of civilisation, the more acute does his sensibility to pain appear to become, or possibly the less he is able to bear it. A savage probably suffers less than a civilised man from any given injury, and hence may display more apparent fortitude. An hysterical woman probably does not suffer more than one with a more healthy nervous system, but she complains more loudly, for she has her feelings less

under control. Race appears to exercise an influence on pain; some of the native races of India appear to suffer far less than Europeans under surgical operations of a similar kind. There are, however, other conditions besides pain that influence the severity of shock.

The sudden occurrence of a severe injury will cause a *physical impression* independently of any emotion or moral influence. The severity and continuance of the shock are usually proportionate to the gravity of the injury, either from its extent or from the importance of the part wounded. Thus, if the whole of a limb be torn away by a cannon-shot, or crushed by a railway train, the shock will be severe from the extent of the mutilation; whilst, on the other hand, if a man be shot by a pistol-bullet through the abdomen, though the extent of the injury be trifling and only a few drops of blood escape, yet the shock will be severe, owing to the importance of the part injured. The Surgeon not unfrequently employs this fact as an accessory means of diagnosis. Thus, if a man break his leg, and at the same time strike his abdomen, and the shock be very serious and long continued, the probability is that some severe injury has been inflicted upon an internal organ; injury of the viscera occasioning more severe and continued shock than a wound of a less vital part.

The **diagnosis** of shock is usually easy, but it is often difficult to determine after a severe injury how much of the patient's condition is due to loss of blood and how much to shock. Restlessness, deep sighing respiration, a sense of dyspnœa, and a somewhat abundant perspiration, are signs indicating that the patient is suffering to a great extent from loss of blood. If the patient is half unconscious and lies perfectly still, with a very small fluttering pulse and regular shallow respiration, it is probable that his condition is due chiefly to shock. The sickness produced by an anæsthetic may closely resemble shock, but it soon ends in actual vomiting, after which the pulse improves and the pallor diminishes. During an operation, however, this condition often causes the Surgeon great anxiety, which is only relieved by the commencement of vomiting.

3. **Shock with Excitement, or Erethitic Shock.**—Three separate conditions seem to have been described under this name. First, a state of shock not sufficiently severe to render the patient insensible to severe persistent pain, as from an extensive burn or scald. There is, then, restlessness instead of the perfect quiet of severe shock under ordinary conditions. If the shock be more intense the patient may show no signs of pain. One of the worst signs in severe burns of children is an apparently perfect freedom from pain. Secondly, the condition of restlessness, dyspnœa, and excitement from profuse hæmorrhage, combined with some degree of shock, has been described under the above name. Lastly, the term has been applied to cases in which the symptoms of traumatic fever manifest themselves before the exhaustion of the shock has passed away. The ordinary symptoms of fever are present, and amongst them delirium is often prominent. The pulse increases in frequency as the fever develops and at the same time its force becomes less. This condition very commonly terminates in death, apparently from exhaustion.

Treatment of Shock.—If the shock be chiefly mental, the patient will usually rally speedily on being spoken to in a kind and cheering manner, or on having some stimulant administered. If the shock be more severe, and be the result of considerable injury, the patient should be laid in the recumbent

position, and the injured part arranged as comfortably as possible; he should be wrapped up in warm blankets, hot bottles should be applied to the feet, and friction to the hands and surface; a little warm tea, wine, or spirits and water, may be administered, provided the insensibility be not complete; if it be complete, the fluid should not be given, lest it find its way into the larynx. In these circumstances, ammonia should be applied to the nostrils, and a stimulating enema administered, or ten minims of ether may be injected hypodermically, and repeated at intervals of about ten minutes if necessary until the patient begins to rally. When there is much pain associated with the shock, a few drops of laudanum may advantageously be given, or a quarter of a grain of morphia administered hypodermically.

After all large surgical operations, a slight condition of shock is not to be regarded as an evil. The feeble action of the heart favours the perfect closure of the small vessels by coagula, and unwise stimulation is not an uncommon cause of hæmorrhage during the first twelve hours.

Operation during Shock.—Whether an operation should be performed during severe shock is a question of considerable importance. As a general rule, it certainly should be deferred until reaction comes on, as the additional injury inflicted by the operation would increase the depression under which the patient is suffering. In some cases, however, the presence of a crushed limb appears to prevent the patient from rallying, notwithstanding the administration of stimulants. In these circumstances the Surgeon would be justified in operating before reaction came on. Here the administration of ether is extremely beneficial; it acts as a stimulant to the nervous system, and prevents the pain and dread of the operation from still further depressing the patient. In long-continued shock, great care is required in ascertaining that there is no internal injury, such as laceration of one of the viscera, giving rise to the depression, but that the shock is really and solely dependent upon the state of the limb.

Prevention of Shock.—In cases in which an operation is likely to be accompanied by much shock, needless exposure of the body to cold must be carefully avoided, and great care taken to limit the loss of blood by the use of pressure-forceps applied to each vessel as it is divided. Ether should be used in preference to any other anæsthetic, and must be given so as to produce complete anæsthesia. Experiments on animals have shown that after the injection of a very small dose of atropin beneath the skin it is impossible to inhibit the heart by stimulating the vagus. It has therefore been suggested that shock might be prevented in the human subject in this way. We cannot, however, expect much from this treatment, for inhibition of the heart by the pneumogastric probably forms but a small element in most cases of shock as it is met with in practice.

TRAUMATIC FEVER.

The term **Traumatic Fever** has been somewhat loosely applied to any febrile disturbance which follows a wound or severe injury within the first week or ten days after its infliction. The exact nature of this febrile disturbance has occupied the attention of numerous observers, amongst whom may be mentioned Billroth, Bergmann, Volkmann, and Lucas-Championnière. Their investigations have shown that a clear distinction must be made between the fever occurring in subcutaneous injuries, or in wounds following a perfectly

aseptic course, and that occurring as a consequence of the absorption of the products of putrefaction from a septic wound. The term "traumatic" may conveniently be retained to indicate the fact that the fever is directly or indirectly the result of an injury, and we may then speak of Aseptic or Simple Traumatic Fever, and Septic Traumatic Fever. The fever that accompanies a true infective process, either general or local, as in pyæmia or erysipelas, has never been included under traumatic fever.

Aseptic Traumatic Fever, or, as it has been called, "*reactionary fever*," commences as soon as the symptoms of shock disappear. As the patient rallies the temperature rises from the subnormal point to which it had fallen, passes the normal and gradually rises from one to two degrees above it. In the majority of cases it reaches its highest point on the second day, and falls again to normal by the end of the third or fourth day, but it may be prolonged to the sixth or seventh. The highest point is seldom above 101° F. The constitutional disturbance is slight, the patient himself often being unconscious of any feeling of illness. In the case of an open wound, if decomposition of the discharges occurs, the simple traumatic fever is more or less masked by the septic fever which commences on the second or third day, and consequently it is best studied in simple fractures and other subcutaneous injuries. Some important observations illustrating the course of simple traumatic fever have been made by Victor Horsley in cases of simple fractures of the larger bones of the limbs. In 168 such cases he found a distinct febrile disturbance in 91 per cent. In most a rapid rise occurred in the first few hours after the injury, the temperature reaching 99·5° F. to 100° F. The rise then continued more slowly, the maximum—varying from 100° F. to 101° F.—being reached in from twenty-four to forty-eight hours. The temperature in most cases then gradually fell, reaching the normal point before the end of the seventh day.

The exact cause of this febrile disturbance is not yet distinctly known. Lucas-Championnière is of opinion that we must look for it in the nervous system, while Bergmann and others believe it to be due to the local development of some substance possessing pyrogenic properties which is taken up from the injured part either by the blood-vessels or lymphatics. (See also p. 194.)

That a febrile disturbance may be of purely nervous origin seems probable when we consider that which follows concussion of the brain, when there is no reason to suspect any actual laceration, that is to say, when the insensibility is of short duration and the recovery complete. In such cases it will usually be found that the thermometer rises to about 100° F., and falls again to the normal point within twenty-four or forty-eight hours of the injury. There is, however, no evidence to show that a prolonged febrile disturbance can be induced by such stimulation of the sensory nerves as occurs in a wound or other injury. On the other hand, we know that severe pain tends to lower, not to elevate, the temperature.

It seems more probable that in the vast majority of cases, at least, simple traumatic fever is produced by absorption of some pyrogenic substance from the injured area, and we have abundant evidence that such substances are formed. It has been shown by Billroth and others that the fresh aseptic serous discharge from a recent wound, injected into the subcutaneous tissue or vessels of an animal, causes febrile disturbance. Köhler, Edelberg, Bergmann, and others, have also shown that the expressed serum from a fresh

blood-clot possesses powerful pyrogenic properties which they attribute to the fibrin-ferment, which it always contains in considerable quantities in a free state. If the ferment be injected in large quantity, other symptoms are developed resembling septicæmia, and often associated with coagulation of blood in the heart or cardiac thrombosis. Clinical experience seems to confirm this view. Large subcutaneous extravasations of blood are usually accompanied by very marked febrile disturbance, and the same has been observed in the transfusion of defibrinated blood. In a large wound, when the drainage is imperfect and an accumulation of aseptic serous discharge takes place, very distinct elevation of temperature is the common result. It is very possible that the application of strong antiseptic fluids to the raw surface of a wound, by increasing the exudation during the first few hours, may slightly add to the fever in some cases, and want of rest or the accumulation of blood-clot in the cavity of a wound may produce a similar effect.

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Nervous Traumatic Delirium usually occurs in persons whose constitutions have been broken by habitual excess in drinking; and in fact, it is in most cases, if not always, an attack of ordinary delirium tremens, induced by the shock of the accident. Most commonly the earliest sign is want of sleep, with a restless nervous manner; in some rare cases it is preceded by a fit of an epileptiform character. The pulse becomes quick, small, and irritable; the surface is cool, and usually covered with a clammy offensive perspiration; in cases uncomplicated by an open wound there is usually no elevation of temperature; should there be fever, the gravity of the case is greatly increased. The tongue is white and furred, and there is usually tremor both of it and of the hands. The delirium is of a muttering, suspecting character; the patient is often harassed by spectral illusions, but will answer questions rationally. Traumatic delirium tremens is sometimes very rapidly fatal. I have known it to destroy life in cases of simple fracture in less than twelve hours. In other cases, death takes place after some days from exhaustion; and the fatal termination is occasionally sudden.

A form of *maniacal delirium* is occasionally met with after operations in persons of great nervous susceptibility, who have been exposed to severe mental strain before the operation. It has been not unfrequently observed after

removal of the breast, especially in those cases in which the patient has long concealed her disease, and finally with a great mental effort submitted to the operation.

In the *Treatment* of nervous traumatic delirium, the essential points are to induce sleep and to keep up the patient's strength. The foul tongue and breath are sufficient indications of the necessity of administering a brisk purgative at the commencement of the treatment; in many cases no sedatives will have any effect till the purge has acted. The motions brought away by the medicine are usually excessively foul. The best sedatives are bromide of potassium, morphia, and hyoscyamus. The bromide may be given in twenty-grain doses, repeated every two or three hours. Morphia may be given in quarter-grain doses, repeated at intervals of four hours, till one grain is reached, or till sleep is induced. The effect of the drug must be carefully watched. It is always better to administer it hypodermically when possible, as in some cases it seems to be imperfectly absorbed from the disordered stomach. Hyoscyamus may be administered in half-drachm doses of the tincture, but it is less effectual than morphia. Both morphia and hyoscyamus may be given in combination with the bromide. Hydrate of chloral has also frequently been used; but it is not so safe a drug as those just mentioned, as an excessive dose may kill the patient suddenly. Sulphonal sometimes succeeds in inducing sleep when other drugs have failed. The Surgeon must use his judgment as to the extent to which the sedatives may be pushed. If they fail to act, it is wiser to discontinue them than to run the risk of giving a poisonous dose. Food is even of more importance than sedatives; so long as the patient can take an abundant supply of good liquid nourishment there is hope of his recovery. Solids must be avoided, as the stomach is never in a state to digest them. If there be much depression, it will usually be advisable to administer some stimulant, that to which the patient has habituated himself being the best. It is sometimes convenient to mix the sedative with the stimulant. If the patient be strong, there is no danger in cutting off all stimulants, even in the case of a confirmed drunkard. After sleep has been induced, the quantity of sedatives must be lessened; but it will often be found necessary to continue them for some time, as there will be a tendency to recurrence of the delirium at night.

The patient should, if possible, be put in a room by himself, and watched by a single attendant. If he is violent, he should be at once put in a strait-waistcoat, as it excites him much less to struggle with an inanimate object than with a couple of men. When the strait-waistcoat is firmly applied, the attendant should keep out of sight as much as possible while watching him. If the injury is a broken bone in a limb, the injured part must be fixed firmly in splints well padded with cotton-wool and swung from a cradle; it must on no account be fixed to the bed, for every movement of the patient would then grind the bones together, and perhaps render a simple fracture compound. The patient seems absolutely insensible to the pain caused by such movements.

These two forms of traumatic delirium, the inflammatory and the nervous, are often found more or less conjoined, and in such cases the prognosis is always grave, as exhaustion speedily sets in; stimulants and abundant fluid nourishment must then be freely administered.

REMOTE EFFECTS OF INJURY.

These may be *constitutional* or *local.*

The **Remote Constitutional Effects** of injuries are of a very varied character. In some cases, persons who have met with serious injury will be found to die suddenly, some months after apparent recovery. In others, the general health fails, and an anæmic and cachectic stage supervenes. In other instances, again, the functions of the nervous system become disturbed; convulsive movements or paralytic symptoms of a slight but persistent character develop themselves, and may become progressive. In these cases, the immediate effect of the injury on the nervous system seems to pass off, while a permanent impression is left. The patient never completely recovers from the effects of his injury; he is never "the same man again;" and, although his health may appear to improve from time to time, yet, on careful investigation, it will be found that there has been a continuous train of symptoms indicative of a disordered state of the nervous system. This condition of general disturbance of the nervous system resulting from injuries, especially such as are attended with great mental shock, is designated "traumatic neurasthenia." It will be considered in the chapters on Injuries of the Head and Spine.

Remote Local Effects.—The possible remote local consequences of severe injuries deserve more attention than they usually receive. There can be no doubt that many structural diseases owe their origin to long antecedent injuries. The nutrition of a part may be modified to such an extent by a blow or wound inflicted upon it, as to induce those alterations in the structure which constitute true organic disease. Thus we occasionally find, on death occurring many months after a severe injury, that extensive local mischief, usually of an inflammatory character, is disclosed, which has evidently been going on in an insidious manner from the time of the accident.

In other cases again, a blow may give rise to severe and long-continued neuralgic pains in a part; or it may be the direct cause of structural disease in bones, joints, or blood-vessels; and, lastly, it may be the starting-point of cancerous or other tumours, many cases of which can be distinctly referred to external violence.

CHAPTER IX.

INJURIES OF SOFT PARTS.

THESE consist of *Contusions* and *Wounds*.

CONTUSIONS.

A **Contusion** may be looked upon as a subcutaneous wound. Great disorganisation of the subcutaneous structures may take place, although the skin, owing to its elasticity and toughness, remains intact.

In contusions there is always **extravasation** of blood into the tissues to a greater or less degree. When slight, this extravasation is termed an **ecchymosis.** The blood is not shed outwardly, but accumulates under the skin in the areolar tissue, or in internal organs, presenting in the former situation the ordinary purplish-black discoloration of a bruise. The arrest of the extravasation is due in great measure to the coagulation of the effused blood closing the torn vessels, and in some cases to the pressure it exerts upon their walls; thus allowing the ordinary process of repair of wounded vessels to take place.

CAUSES.—Contusions may result from *direct pressure*, as when a part is forcibly squeezed; from a *direct blow*, usually by a hard blunt body; or from an *indirect blow*, as when the hip-joint is contused by a person falling on his feet from a height.

Compression of the parts injured is always necessary to produce a contusion. This compression may occur between the force on one side and a bone as the resisting medium on the other; or the part injured may be compressed and contused between two forces in action—as when the hand is caught between two revolving wheels; or between a force in action and a passive medium—as by a wheel passing over the limb and crushing it against the ground.

DEGREES.—The amount of extravasation of blood consequent on a contusion will depend upon the force causing the bruise, the vascularity of the part, and to a considerable extent upon the state of health of the individual. In persons out of health, with soft tissues, bruising very readily occurs. Contusions are of various degrees: they may be arranged as follows:—1, **of the Skin only**; 2, with **Extravasation into the Areolar Tissue**; 3, with **Subcutaneous Laceration of the Soft Parts**; and 4, with **Subcutaneous Disorganisation of the Soft and Hard Parts.**

In the *first degree*, the blood is effused merely into the skin, producing ecchymosis or bruise; the colour of which varies at different periods from purplish-red to greenish-brown, this variation being dependent upon changes that take place in the pigment as the blood undergoes absorption.

In the *second degree*, the extravasated blood distends the spaces of the areolar tissue, and there coagulates, forming a doughy swelling. In other cases in which the areolar tissue is torn either by the injury or by the

extravasation, a bag of blood may be felt, fluid and fluctuating, under the skin. Under ordinary circumstances the effused blood is gradually absorbed; but if it communicates with the air by an external wound, it will undergo putrefaction, unless special antiseptic precautions are taken to prevent this, and will excite inflammation and suppuration around it, the clots being discharged mixed with pus. In some cases the clot resulting from extravasated blood may ultimately be replaced by new connective tissue, and thus some permanent induration may be left. In other cases the extravasated blood may give rise to a sanguineous tumour, **Hæmatoma**; the blood, which may remain fluid for months, or even years, slowly deposits its fibrin upon the tissues in which it is lying, thus forming an imperfect cyst-wall, while the fluid contents become dark and treacly. According to some pathologists, this imperfect wall may develop into well-formed fibrous tissue, and the contents may become colourless from complete absorption of the blood pigment, and thus a definite cyst with serous contents may be formed in the site of the extravasated blood. In some cases the contents are grumous rather than serous.

In the *third and fourth degrees* of contusion, the laceration and disorganisation of structures often lead to sloughing and suppuration, or to rapid gangrene of the parts, or to hæmorrhage, ending in fatal syncope; or, when the contusion is of an internal organ, this hæmorrhage may prove fatal by taking place into the serous cavities. When the contusion is superficial, the hæmorrhage is subcutaneous, and though abundant, is rarely in sufficient quantity to influence the heart's action. In one remarkable case, however, in which a schoolmaster was convicted of manslaughter for beating a boy to death with a stick, and in which I was called upon to make a *post-mortem* examination, death had evidently resulted, in a great measure at least, from this cause: the subcutaneous areolar tissue of the four limbs being extensively torn away from the fasciæ, and uniformly filled with extravasated blood, whilst the internal organs were in an anæmic condition, even the pulmonary vessels and the cavities of the heart being emptied of blood.

An extravasation of blood, when of any considerable size, is almost invariably followed by a distinct elevation of temperature, often amounting to two or three degrees. It sets in soon after the injury, and subsides by the fourth or fifth day or earlier. The fever of suppuration is more severe, sets in later, and does not subside till the pus is evacuated.

Diagnosis.—This is not always easy. The more severe degrees may be mistaken for incipient gangrene, the discoloration not being very dissimilar, and the resemblance being sometimes increased by the formation of blebs upon the skin containing serous fluid more or less darkly coloured with blood: but the part, when simply contused, preserves its temperature and vitality. In some cases the extravasated blood has a hard circumscribed border of clot, and is soft in the centre, which in the scalp resembles somewhat a depression in the subjacent bone.

The diagnosis of old cases of extravasation, leading to hæmatoma, from abscess or malignant disease, is not always easily made by tactile examination alone; but the history of the case, exploration with a grooved needle, and examination of the contents of the tumour under the microscope, will always clear up any doubt that may exist.

Treatment.—In the first two degrees of contusion our object should be to arrest the hæmorrhage from the ruptured vessels as speedily as possible, and

afterwards to promote the absorption of the extravasated blood. For the first purpose cold applications are of especial service. Ice may be applied in severe cases, but its use must not be continued too long, lest it lead to sloughing of the bruised tissues. In slight cases a lotion composed of one part of spirits of wine to eight or ten of water may be constantly applied. After all hæmorrhage has ceased, cold is of little use in promoting absorption, and the part may be wrapped in cotton-wool or hot fomentations may be applied. Leeches should not be applied to a bruised part; they cannot remove the blood that has already been extravasated, and they often set up irritation, which leads to suppuration. A bag of blood, however soft and fluctuating it may feel, should not be opened so long as there is any chance of its being absorbed. If once it be punctured and unpurified air or water be allowed to enter, suppuration may be set up in it. The fluid blood may, however, in such case be safely removed by means of the aspirator, a large needle being used, and the puncture being closed with collodion. If signs of inflammation occur, the parts becoming red, hot, and throbbing, free incisions should at once be made with antiseptic precautions.

In the third and fourth degrees of contusion, it is often useless to attempt to save the life of the injured part; but, if this is attempted, much may be done to prevent the fever and suppuration that sometimes attend the separation of the sloughs. The skin, being in such cases unbroken, must be washed with a solution of carbolic acid (1 in 20), or perchloride of mercury (1 in 500), after which an antiseptic dressing may be applied, beneath which the sloughs will separate with scarcely any febrile disturbance, and but little suppuration.

Disorganising contusions of the most severe kind may be recovered from *provided there be no external wound*, even though the soft structures of the limb or part be extensively crushed, the bones comminuted, and the joints opened. It is not the subcutaneous lacerations and disorganisations that are to be dreaded; so long as the main blood-vessels of the part injured are intact, these may be recovered from. The admission of air, bearing with it the causes of decomposition, into the interior of a badly injured limb constitutes the great danger. If this can be avoided there is little fear of undue inflammation being excited; but if impure air or water be admitted to the lacerated tissues, putrefaction followed by suppuration and sloughing may be set up, and the safety of the patient thus seriously imperilled. In such cases as these, amputation is usually the sole resource, unless the progress of the mischief can be arrested by efficient antiseptic treatment.

The difference between the effects of a subcutaneous laceration and one accompanied by open wound is well exemplified in the cases of a "simple" and a "compound" dislocation. In the former case, although the ligaments and capsular muscles are extensively torn, often with great extravasation of blood, repair takes place without any serious trouble; whilst in a compound dislocation, in which air has been admitted and has given rise to putrefaction of the extravasated blood and the inflammatory exudation, the most extensive suppuration necessarily ensues, and joint, limb, or life is in great danger of being lost.

Contusions of internal organs are always very serious, and require special treatment, according to the part that is affected and the extent of its injury.

Strangulation of Parts.—Strangulation may be sudden and complete, as

when a nævus or pile is ligatured by the Surgeon. The circulation is then immediately arrested, and gangrene results, not preceded by swelling or marked alteration in colour. Accidental strangulation is more commonly gradual. In such cases, the first effect of the constriction is to prevent the return of the venous blood; this occasions serous effusion and œdematous swelling. If relief be not afforded to the circulation by the removal of the constriction, distension of the vessels, stagnation of the blood, and gradual loss of vitality of the part terminating in gangrene will ensue. In many cases in which the strangulation is relieved by the Surgeon, the loss of vitality is far advanced but not complete, and the restoration of the circulation is then followed by inflammation, varying in intensity with the degree of damage that the tissues have suffered. This is, indeed, merely an illustration of the fact experimentally demonstrated by Cohnheim, that arrest of the circulation in a rabbit's ear gives rise, when the circulation is restored, to inflammation, the intensity of which can be determined by the duration of interference with the flow of blood. The most familiar example of this condition in actual practice is the inflammation of the gut that so frequently follows reduction of a strangulated hernia.

The treatment of strangulation consists in at once dividing or removing the cord or ring, as the case may be. Usually this is easily done, but in some cases it is attended with no little difficulty. This happens especially when a small ring has been hurriedly put on a wrong finger, or when the penis has been drawn through a brass ring. In such cases as these the swelling renders the removal of the foreign body difficult. The finger-ring may usually be removed by slipping a director under it, and clipping or filing it across upon this. Sometimes the following popular plan may advantageously be adopted. A strong silk thread is carefully bound round the finger as tightly as possible from the tip down to the ring, under which the free end is carried with a needle: the thread is then slowly untwisted, and the ring is thus carried upon it off the finger. Curtain or other brass rings compressing the root of the penis have been known slowly and gradually to cut through the organ, without destroying its vitality or rendering the urethra impervious, but so fortunate a result is altogether exceptional; in the great majority of such cases, unless the ring be speedily cut off, mortification of the organ will ensue, and may be followed, as it has been in some instances, by the death of the patient.

Subcutaneous Wounds.—The remarks that have just been made with respect to the effects of the admission of air into extravasations of blood and subcutaneous lacerations or contusions, apply with equal force to subcutaneous wounds; indeed such lacerations, ruptures, and injuries are, properly speaking, subcutaneous wounds; that is to say, bones, muscles, ligaments, tendons, and blood-vessels may be broken, torn, contused, and ruptured, and yet, if the skin covering the parts be unbroken, complete repair may take place without the inflammation at any time passing beyond the simple traumatic or adhesive stage, and without more than the slight degree of traumatic fever inseparable from all serious injuries, which in the slighter injuries would not be recognisable.

[illegible] takes advantage of this most important fact in many of his [illegible]h are performed *subcutaneously;* that is to say, the narrow [illegible]fe is introduced through a puncture in the skin, tissues are

freely divided, and on the withdrawal of the knife the wound is so closed either by the approximation of its valvular edges, or by the pressure of a compress, that the entrance of air is prevented, and thus healing takes place by the first intention, without constitutional disturbance, as in a subcutaneous laceration. This is the principle on which the operation of tenotomy is performed.

The only treatment needed in a subcutaneous wound is rest and protection of the skin. The unbroken skin is a more certain antiseptic than any surgical dressing.

OPEN WOUNDS.

A wound may best be defined, in the words of Wiseman, as "a solution of continuity in any part of the body, suddenly made by anything that cuts or tears, with a division of the skin."

Surgeons divide wounds into five kinds, **Incised, Lacerated, Contused, Punctured,** and **Poisoned.**

INCISED WOUNDS.

Incised wounds are those made by a sharp-cutting instrument such as a knife or sword. They may vary in extent from a simple superficial cut to the incision required in amputation at the hip-joint. They may be simple, implicating merely integument or integument and muscle; or they may be complicated with injury of the larger vessels and nerves, or of important organs.

SYMPTOMS.—All incised wounds give rise to three symptoms; viz. Pain, Hæmorrhage, and Separation of the lips of the wound.

The **Pain** in an incised wound is usually of a cutting, burning, or smarting character. The intensity of the pain varies with the abundance of the nervous supply of the part; a wound of the hand, for instance, is much more painful than one of the skin of the back.

The amount of **Hæmorrhage** necessarily depends upon the vascularity of the part as well as on the size of the wound. The proximity of the part wounded to the centre of the circulation, or to a large vessel, has also a very considerable influence, different parts of the same tissue bleeding with different degrees of facility; thus the skin of the face yields when cut more blood than that of the leg. Again, the same parts will pour out a larger quantity of blood when the vessels are dilated in consequence of local irritation than when they are in their normal condition.

The **Separation of the Lips of the Wound** depends on the tension and the position of the part as well as on the elasticity and vital contractility of the tissues; it is also influenced by the direction of the incision, according as this is parallel to the axis of a limb or muscle or across it. It is greatest in those parts that are naturally the most elastic or that possess the highest degree of tonicity; thus the muscles when cut retract some inches, the arteries and skin gape widely when divided, whereas in the case of ligaments or bones, no retraction takes place.

MANAGEMENT OF INCISED WOUNDS.—In the treatment of an incised wound, we must always endeavour to procure union by first intention (p. 286) between a portion, if not the whole, of the surfaces, for reasons already given. This

result depends partly upon the constitution of the patient; it is an error to suppose that success is entirely dependent on local conditions and the management of the wound itself. In some constitutions it is impossible, under the most favourable circumstances, to obtain it. The sounder the constitution, the more readily will union by the first intention take place; and in all cases it is favoured by the removal of all sources of irritation from the system, and by the adoption of a plain and nutritious diet. Repair, like all other physiological processes, is attended with an expenditure of force directly proportional to the extent of the injury to be repaired, hence a lowering plan of treatment is to be avoided, though the opposite error of overstimulation is equally to be deprecated. Before any operation, when possible, the patient should be prepared by being kept for some days upon a plain diet. He should take moderate exercise, and regular action of the bowels should be ensured. The condition of the kidneys should also be ascertained by examination of the urine. In cases of accidental wound we must keep the patient quiet, put him on a moderate diet, and be very cautious in the administration of stimulants, as they have a great tendency to interfere with union by the first intention by increasing the force of the heart and exaggerating the early exudation.

Local Treatment.—In the treatment of wounds the first four days form the most important period, and the fate of the wound, whether it shall heal by first intention or by the slower process of granulation, is practically determined in the first twenty-four hours. It has already been pointed out in the chapters on Inflammation and Repair that, as the necessary result of the injury done by the knife, a limited traumatic inflammation is set up, accompanied by abundant exudation of liquor sanguinis and migration of corpuscles; the liquid exudation coagulates, the serum drains away, and the coagulated fibrin with the white corpuscles remains behind, forming the "plastic exudation" which serves as the first bond of union. This process *must* occur, but it should be completed within the first twenty-four hours, at the end of which time the tissues should have recovered from the damage done by the knife, exudation should cease, and the period of traumatic inflammation should be at an end. Should any fresh source of irritation be brought to bear on the surfaces of the wound the inflammation will persist, the migration and exudation will continue, pus will form instead of the desired plastic exudation, and all adhesion between the surfaces is prevented. The sources of irritation against which we have to guard are—first, *mechanical*, viz. the presence of foreign bodies, the tension from accumulation of blood-clot or discharges, and friction of the surfaces against each other; secondly, *chemical*, the products of putrefaction and the persistent action of powerful antiseptics; and thirdly, *specific infective poisons*, as erysipelas, hospital gangrene, some forms of pyæmia and septicæmia. It is evident, therefore, that, in accordance with these principles, the following are the essential features of the treatment of a wound:—1, Arrest hæmorrhage perfectly; 2, Remove all foreign bodies and clean the wound; 3, Bring the surfaces accurately into contact; 4, Provide perfect drainage for the serous discharge which must be poured out during the first twenty-four hours; 5, Maintain perfect rest of the part; 6, Prevent decomposition of any discharge that may form between the surfaces, avoiding the constant action of an irritating antiseptic, and guard the patient against the chance of infection from unhealthy or specific inflammations in the wounds of others.

The healthy traumatic inflammation which results from every wound is very limited in extent, and consequently gives rise to such slight local symptoms that it may clinically pass unnoticed, and it has sometimes been ignored; the term "inflammation of a wound" being applied to the process only when it extends more widely so as to cause redness, swelling, heat and pain easily recognisable by the most superficial observer. Clinically this may be convenient, but pathologically it is inaccurate. The process by which the plastic exudation is formed is an example of simple traumatic inflammation not spreading beyond the area injured; the later process is a spreading inflammation due to various sources of irritation which have been allowed to act on the wound after its infliction.

There is no subject in Surgery which has undergone more frequent modifications from the earliest periods of which we have record than the local treatment of wounds. The first, and perhaps the instinctive, method of treating a wound was to close it up at once and to exclude the air by means of a mass of clay, of chewed leaves, or of cow's or camel's dung. The wound was further protected from the air by pouring oil into it, and putrefaction was limited by the use of wine or balsams. At a later period in the history of our art, tents of various kinds were used in order to prevent the injurious accumulation of discharges, which might decompose and putrefy. The closure of the wound and the prevention of putrefaction in its discharges by the use of spirituous and stimulating antiseptics, or by facilitating the escape of the secretions, were the means employed from the most remote antiquity. That these methods were in many cases highly successful there can be no doubt; and it is still these four great principles, the closure of the wound, the prevention of putrefaction, the facilitation of the escape of discharges, and the maintenance of perfect rest between the opposed surfaces, that guide us in the treatment of all wounds, however different may be the means by which we endeavour to carry them out.

In the local treatment of all incised wounds there are six chief indications, which will be considered in the following order: 1, the *Arrest of Hæmorrhage*; 2, the *Removal of Foreign Bodies*; 3, the *Coaptation of the Sides of the Wound*; 4, the *Provision of Perfect Drainage*; 5, the *Maintenance of Perfect Rest*; 6, the *Prevention of Decomposition of the Discharges and Infection of the Wound*. These we shall consider more in detail.

1. **Arrest of Hæmorrhage.**—If bleeding be general from the surface it may be stopped by exposure to the air, by elevation of the wounded part, by accurate and firm coaptation maintained by the pressure of a well-applied bandage, and by the use of cold, heat, or other styptics. Arterial bleeding must be arrested by the means described in Chapter XIV. In making choice of a hæmostatic, preference is to be given to that which will interfere least with union by the first intention. Thus, among styptics, hot water or cold, in the shape of ice or of rags wrung out of cold water, is to be preferred to others, such as the perchloride of iron, which are all more or less caustic and irritant. Again, torsion should be employed when possible rather than other means; and if the ligature be used, it should be of some material which can be absorbed and will not offer any obstacle to union by the first intention.

2. The **Removal of Foreign Bodies,** such as dirt, pieces of stone and glass, spicula of bone, coagulated blood, &c., is best effected by allowing

a stream of water, to which some efficient antiseptic, as carbolic acid, corrosive sublimate, or iodine has been added, to fall upon the part from a sponge or irrigator, all rough handling of the wounded tissue being avoided as much as possible. Sharp and angular bits embedded amongst the tissues should be removed with forceps. Above all, this cleansing of the wound is to be done thoroughly, and once for all; a comparatively insignificant body, if overlooked at this time, may effectually prevent adhesion, whilst disturbance of the wound after it has been once closed destroys the layer of plastic exudation which ought to form the early bond of union.

3. The next and most important indication to fulfil, is the **Coaptation of the Opposed Surfaces** as accurately as possible.

As a general rule, the sides should not be brought together until all hæmorrhage has ceased; if, however, there is but slight oozing, this may be arrested by their approximation, and the pressure thus exercised on the bleeding vessels.

The surfaces should be gently brought together so as thoroughly to exclude all air and superfluous moisture from the deeper portions of the wound, the skin-margin being the last to be adjusted; due attention should at the same time be paid to relaxing the parts by position, so that there may be no gaping of the lips nor tension on the sides of the wound. For the purpose of keeping all in position, *sutures*, *plasters*, and *bandages* are employed.

Sutures are the best means we have of bringing the edges of a wound in close apposition, but if drainage be not carefully attended to they may favour bagging, by causing superficial union, whilst the deeper parts still gape. A suture is in itself almost unirritating, but it can become irritating in two ways—first, by being applied too tightly, or by becoming tight in consequence of swelling, and thus causing tension; and, secondly, by absorbing the products of putrefaction, and thus acting as a chemical irritant. The first condition is common to all sutures, of whatever material they may be made; the second can be avoided by the use of metallic or other non-absorbent substances, and by efficient antiseptic treatment of the wound. The chief non-absorbent materials employed are well-annealed silver wire of various degrees of stoutness, silkworm-gut, and horsehair. In cases treated antiseptically silk is largely used for sutures; it should be that known as dentists' or twisted silk, and should not be waxed. It may be thoroughly sterilised by boiling for half an hour, and should then be kept ready for use in carbolic acid solution (1 in 20). Silkworm-gut and horsehair are excellent materials for sutures, and are readily made aseptic by immersion for a few minutes in carbolic lotion (1 in 20); they are especially useful in plastic operations on the face. Fine chromicised catgut has the great advantage of not requiring to be taken out, as the deep part of the stitch becomes absorbed if it is protected from decomposition. A non-absorbent suture should always be used in cases where much discharge is expected or where the antiseptic method cannot be employed; thus silver wire is the best suture for the operation of cleft palate. The thickness of the suture will vary with the purpose for which it is used; thus for the support of large flaps in an amputation the suture must be thick, whereas for the accurate adjustment of the skin in a wound or plastic operation about the face the finest sutures are employed. Needles of every variety are used; they may be straight or variously curved, and it is sometimes convenient to have them set in a handle with the eye near the point.

instead of in the ordinary position. For silver sutures a special form of needle is used, having grooves to receive the wire when doubled back after passing through the eye.

The modes of applying sutures are various; but the one most commonly employed in all cases involving the integument is the **interrupted**, which consists of the introduction of as many single stitches as may be necessary to close the opening. The distance between the stitches must be determined by the amount of tension and by the necessities of drainage. If there is even moderate tension, it is better to insert a few sutures of a thicker material, or "sutures of support," extending deeply into the subcutaneous tissue, the needle being made to pierce the skin an inch or more from the edge of the wound. These sutures are first tightened to such an extent as just to approximate the lips of the wound, which may afterwards be brought more accurately into contact by finer stitches or "sutures of apposition" (Fig. 27). If ample provision is made for drainage by the use of tubes the edges of the wound may be brought very closely in contact, otherwise in large wounds there should not be less than one inch between the stitches. When, as in some plastic operations, one edge of the wound is at a higher level than the other, if it is desired to depress the higher edge, the stitch must be so passed that it shall include a larger piece of the lower: if to raise the lower edge, the chief hold must be on the higher. In longitudinal wounds, the first stitch should be inserted in the centre: but, if there be any angles, as must be the case after crucial incisions, the extremities should be first closed. The fastening is effected in the case of silk by tying a reef-knot, and in that of wire, by tying a half knot and then crossing the two ends over each other, by which two small hooks are made which hold very firmly; in both instances, the ends are cut off short. The knot or twist must not lie over the line of incision, but on one or other side of it. The time that the sutures should be allowed to remain must depend greatly on the nature and progress of the wound. A septic silk stitch must be removed in from two to three days; an aseptic silk or a silver suture may be left in as long as it serves any useful purpose, provided it is causing no irritation. A tight stitch necessarily causes irritation; in from twenty-four to forty-eight hours it will be surrounded by a blush of redness extending an inch or more from the edge of the wound, and by the third day it will have commenced to cut its way out by ulceration. When this occurs, no good purpose can be served in most cases by retaining it, and it should at once be removed. All deep stitches should as a rule be removed not later than the third day. In withdrawing sutures, the knot or twist should be raised by forceps, and the thread divided on one side of it; gentle traction on the knot, the forefinger of the other hand being placed close to the point of exit in the skin, to prevent disturbance of the newly formed granulation-tissue, will then suffice to draw the suture out. When wire has been used, the bend in it should be straightened as much as possible before pulling it out.

In the **continuous suture**, or glover's stitch, the thread is carried on from stitch to stitch, instead of being detached from the needle, and fastened off as in the interrupted suture. Silk is most conveniently employed. The chief disadvantage of this form of suture is, that, if one stitch cuts through, the others may become relaxed. It is, however, often used for the closure of large wounds, after the insertion of a few deep interrupted sutures of support.

The *Button-Suture* is sometimes used as a deep supporting stitch where there is much gaping of a large wound. It consists of a thick silver wire penetrating deeply through the subcutaneous tissue and passing through the skin from one inch and a half to two inches on each side of the wound. Each end of the wire is passed through an oval piece of sheet lead perforated with a hole in its centre; on the button are projecting wings round which the wire can be twisted after it has been brought through the hole. The two buttons are drawn together and maintained in position by twisting the wire round the wings in such a way as to bring the edges of the wound in sufficient apposition to allow of the finer stitches being inserted without undue tension. The button diffuses the pressure over the whole area upon which it presses, and thus a considerable degree of traction may be applied without causing sloughing. It is especially useful after the excision of malignant tumours with a portion of skin.

The *twisted* or *figure-of-8 suture* is frequently used in cases of hare-lip, and occasionally in other plastic operations. A slender soft iron pin, with a steel point, is introduced through each lip of the wound, at a distance of about half an inch from the margins; and whilst the edges are held in contact, a piece of silk twist is passed in a figure-of-8 round the pin, care being taken not to draw it too tight, nor to compress the soft parts between the needle and the thread, lest sloughing ensue. The projecting ends of the pin are now cut off with pliers, and the skin beneath them protected with plaster.

The pin takes the tension off the suture, so that it is less likely to cut its way out than the interrupted suture. It should be withdrawn in about forty-eight hours.

In closing extensive wounds involving the division of muscular planes, it is often advisable to bring the separate layers into apposition by **buried sutures** of silk or catgut. These must be very carefully sterilised, and are left *in situ*.

Plasters are very rarely employed as a means of bringing the edges of a freshly-made wound into contact. They are, however, sometimes very useful for supporting the tissues on either side of a wound and thus ensuring more perfect rest, and may advantageously be used to prevent the wide separation of the edges of a wound, in which union by first intention has failed to take place. Resin, soap, and isinglass plasters all possess peculiar properties, fitting them for use in particular cases. The American rubber-plaster, which adheres with great tenacity without being either wetted or warmed, will be found very convenient. It will not stick to a wet surface, but if once applied is not easily loosened by discharges, as it is a waterproof material.

Strapping used in an antiseptic dressing should be previously dipped in a basin containing a pint-and-a-half of boiling water in which an ounce of carbolic acid has been dissolved. All superfluous hair having been removed, and the surface dried, each strip should be laid down evenly between the points of suture when these have been used, so as to compress each side of the wound equally. In removing the plaster both ends should be raised at the same time towards the wound, and the strip should then be taken off without either lip of the wound being unduly dragged upon. The strips should be allowed to remain undisturbed as long as possible, and each one replaced before the next is removed.

When the edges of the wound have been brought together, nothing main-

tains the perfect coaptation of the deeper parts so perfectly as the uniform elastic pressure of a mass of cotton-wool, or some similar substance, surrounded by a bandage evenly and firmly applied. This forms a most important feature in some of the methods of treating wounds, to be described immediately.

4. **The provision for Perfect Drainage.**—In every wound which has been closed by sutures there is a danger that the deep part may become distended with blood or serous exudations. Before finally closing a wound it is essential that the hæmorrhage be very thoroughly arrested, and considerable time must often be spent in obtaining this result. Again, by the firm elastic pressure of a large cotton-wool dressing, the early serous exudation can be greatly diminished, the surfaces of the wound being brought into perfect apposition, and the vessels and lymph-spaces closed early by plastic exudation. By most careful attention to these two points—thorough arrest of hæmorrhage and application of uniform pressure—extensive wounds may heal throughout by first intention without any provision for drainage having been made. Such a result cannot, however, be ensured; oozing of blood may occur after the wound is closed, and in many situations it is impossible to apply uniform pressure sufficient to influence the amount of the serous exudation. Hence provision must be made for drainage in most cases, and the value of a "*drainage-tube*" cannot be overestimated as a safeguard against the accumulation of decomposable fluids in the wound, which prevents the cohesion of its opposite sides, and exposes the patient to the danger of septic contamination. In a wound healing by first intention the tube has served its purpose at the end of twenty-four or forty-eight hours, and it may then be removed. Its use should never be omitted, if the wound be deep and irregular, or if there be danger of bagging under a flap. In operations the wound should, whenever possible, be made in such a direction as to facilitate drainage.

5. **The Maintenance of Perfect Rest.**—One important point in the management of every wound is to maintain the injured structures, as much as possible, in a state of *rest*. This is to be done by position, by refraining from disturbing the parts unnecessarily, and by the adoption of some mode of dressing that requires to be changed but seldom. In some cases, *Compresses* of wool or gauze may be so disposed as to aid in keeping the sides in apposition; the *bandages* should be applied over them so as to exert a steady well-regulated pressure, without impeding the free circulation of blood in the part. The elastic pressure of a large mass of cotton-wool as applied in some of the forms of dressing to be described hereafter maintains rest in the highest perfection.

In the treatment of wounds on the limbs the use of a *splint* is often necessary.

6. **The prevention of decomposition of the discharge and of infection of the wound** must be carried out by means founded on the principles already laid down when treating of the causes (p. 172 *et seq.*), and the prevention, (p. 204 *et seq.*) of inflammation.

METHODS OF TREATING WOUNDS.

It is impossible to make more than brief reference to those various methods employed by Surgeons in the treatment of wounds before the introduction of the antiseptic method by Lister.

The **Occlusion Methods** had for their object the exclusion of air from the wound, but the means adopted to obtain this result necessarily shut in the discharges, and thus tension, followed by inflammation and suppuration, commonly occurred. There is no real analogy between this mode of treatment and the process of scabbing, in which the discharge drains away and dries to form the scab. The application of an occlusive dressing can only be justified in the treatment of a small clean cut, and many wounds which might have healed without trouble, if properly treated, have been rendered serious by the "bit of sticking-plaster" applied in a chemist's shop.

Collodion is the only material commonly employed in the present day as an occlusive dressing; in applying it the edges of the wound must be carefully held together and the skin around it thoroughly dried. *Styptic Colloid* has the further advantage of being hæmostatic and antiseptic.

The **Open Treatment** consisted in the application of no dressing of any kind. Wounds so treated often ran a perfectly aseptic course, but the result could not be relied upon. Rest was obtained with some degree of perfection, and the drainage was often good, but, if the discharges were too copious to allow them to dry, decomposition with suppuration almost necessarily followed.

The **Simple Water Dressing** advocated by Liston was a mode of treatment extensively adopted until less than thirty years ago. This method differed from the open treatment only in that the wound was covered with lint, which was kept constantly moistened with water. The discharges were thus prevented from drying, and putrefaction was encouraged. I have, however, seen many large wounds such as those of amputations, or after excision of the breast, heal almost by the first intention, without any suppuration except along the track of the ligatures.

The **Dry Lint Dressing** was used by Syme and many others before the introduction of antiseptic treatment. It consisted of a pad of dry lint placed on each side of the wound, so as gently to press the surfaces together without interfering with the exit of discharge. Over these was placed another piece of lint about three layers thick, and the whole was surrounded with a bandage. This was left untouched for three or four days, by which time it was usually soaked with the discharges and had become more or less offensive from decomposition. This mode of treatment secured rest, apposition, and drainage, and perhaps delayed decomposition by drying the discharges to some extent. Very good results were often obtained by it, but suppuration, followed by pyæmia, was no uncommon occurrence.

The **Cotton-Wool Dressing** was introduced by A. Guérin, of Paris. In this mode of treatment, the wound having been cleaned and its edges carefully approximated, and if necessary a drainage-tube inserted, the whole part is enveloped in a huge mass of cotton-wool, a foot or more in thickness. Over this a bandage is forcibly applied, so as to compress the wool to about half its previous thickness. The dressing is then left undisturbed for a fortnight or three weeks. The temperature is carefully watched during this period, and should there be any considerable rise after the third day the dressing must be removed at once. Severe pain would be another indication for looking at the wound. The principle of the dressing is this: accurate coaptation of the surfaces and the most perfect rest are obtained by the uniform elastic pressure of the cotton-wool; the early exudation is much diminished in quantity, partly

by the pressure and partly by the early adhesion of the opposed surfaces, and such discharge as there is escapes between the edges of the wound and is absorbed by the wool and there dried, and thus prevented from decomposing: all infection from without is prevented by the filtration of the air should any circulate through the mass of cotton-wool. By this treatment admirable results are often obtained, the wound healing rapidly and painlessly, leaving a simple linear cicatrix. The prevention of putrefaction is, however, uncertain; if the discharge is small in amount, and becomes completely dried, the case will run an absolutely aseptic course; more commonly there is a very offensive smell, sometimes that of ordinary putrefaction, sometimes quite peculiar. With this there is some septic fever during the first few days. Guérin's dressing has undergone some modifications, and its principles, as will be seen hereafter, have been adopted in some forms of antiseptic dressing. The substitution of absorbent wool, *i.e.* cotton-wool completely deprived of grease, for common cotton-wool, has rendered the drying of the discharge and the consequent prevention of decomposition more perfect, but even with this it is by no means certain.

In all the foregoing methods no chemical antiseptic is used in the dressing; and the prevention of all evils which follow decomposition of the discharges is but imperfectly accomplished.

The **Antiseptic Treatment of Wounds,** as introduced by Lister, has for its object the absolute prevention of decomposition of the discharges by the application to practice of the germ theory of decomposition. The theory has already been described so fully that it remains only to show the mode of its application. The practice does not necessitate the use of any special antiseptic agent, nor of any special material for dressing; any method of treatment which entirely prevents decomposition, without the constant contact of the antiseptic agent with the raw surface, carries out the principle. The term "aseptic" has sometimes been applied to the various methods of treatment in which the prevention of decomposition is carried out in this way to distinguish them from those in which the cavity of the wound is constantly irrigated or frequently syringed out with an antiseptic fluid.

Every accidental wound which has been exposed for some time before it is seen by the Surgeon will probably contain, deposited in it from the air, the organisms which cause decomposition. Still more certainly will this be the case if dirt has been carried in by the instrument inflicting the wound, or if it has been washed with common water. The first step in such a case is, therefore, to destroy the organisms by washing the surfaces with an efficient antiseptic solution. In the original antiseptic treatment, as introduced by Lister, carbolic acid was the agent used, but at the present time solutions of perchloride of mercury are sometimes employed, and some Surgeons prefer a weak solution of iodine (Tr. Iodi ʒij. Aq. Oj.). In the following description of an antiseptic dressing carbolic acid only will be mentioned, but it must be remembered that a solution of perchloride of mercury, 1 in 1000, may be substituted for the carbolic acid 1 in 20, and one of 1 in 2000 of the former for 1 in 40 of the latter, except in the spray and for instruments. In a prolonged operation or in irrigating a large wound it is safer to use a still more dilute solution of mercury. If the injury be a simple incised wound with smooth surfaces, this may be done with a sponge or with a simple irrigator; if it be irregular, as in a compound fracture, it is best carried out by means of a syringe with a piece of soft india-

rubber tubing on its nozzle. The tubing is stiff enough to penetrate any existing cavity, but not so stiff as to force a way for itself. Care must be taken, in injecting the wound, not to squeeze the lips together so as to cause high pressure in its cavity, for the lymph-spaces in the neighbourhood may become injected with the solution, and unpleasant inflammation may follow. The whole of the parts which will be covered by the dressing should be well washed with the solution. If the wound be on the hand or foot, great care must be taken to clean the nails and between the digits. If the wound is on the head or any other hairy part, the hair must be cut away and the skin shaved. Then, protecting the wound as far as possible, the surrounding skin must be cleaned with soap and hot water or with a weak solution of ammonia and then well washed with the antiseptic solution.

In the case of an operation, the *skin* is first cleansed with soap and hot water, and, if it be unusually greasy, turpentine or ether may be used. Carbolic lotion (1 in 20) is now freely applied around the seat of the intended incision ; this is far preferable to mercurial lotions, which run off greasy skin without thoroughly wetting it. The part should, if possible, be wrapped in a towel wrung out in the 1 in 40 solution for at least half an hour before the operation.

This being done, it is necessary to prevent the entrance of organisms into the wound during the operation. The possible sources of contamination are the Surgeon's hands, the instruments, the sponges, the ligatures, and, lastly, the air.

The *hands* of the Surgeon and his assistants must first be carefully washed in soap and water, with a free use of the nail-brush, and afterwards thoroughly dipped in the 1 in 40 solution ; and the dipping must be repeated whenever the hands have been exposed to the air unprotected by the lotion.

The *instruments* should be placed in a bath of 1 in 20 carbolic lotion, which may be diluted to 1 in 40 at the commencement of the operation by the addition of an equal quantity of boiled water. Each instrument when done with should be at once replaced in the lotion. Instruments are now frequently sterilised by means of heat. This can most conveniently be done by boiling them in water for at least a quarter of an hour before placing them in the carbolic solution ; or they may be exposed to a dry heat of 120°—140° C. for an hour in a specially-constructed stove, or better to the action of superheated steam. To allow of these methods of disinfection, instruments are now made of metal only, and as far as possible in one piece. After an operation all instruments must be thoroughly scrubbed with soap and water and carefully dried. In private practice sterilisation by boiling can be easily carried out.

The *Sponges* must be prepared as before described (p. 40), and must be freshly squeezed out in 1 in 40 solution when handed to the assistant. The *ligatures* should be composed of either silk or catgut prepared as described in Chapter XIV. ; or the hæmorrhage may be arrested by forci-pressure and torsion, and the use of ligatures entirely avoided.

The risk of contamination of a wound by organisms floating in the *air* was at one time undoubtedly exaggerated ; it can be obviated by wetting the surface of the wound with the antiseptic lotion at intervals during the operation and well washing it out at the end. As a mode of irrigating not only the wound but the surrounding air, and the hands of the Surgeon and his

assistants, Lister invented the plan of operating under a spray of carbolic acid. The spray may be produced by a Richardson's ether-spray-apparatus filled with a solution of carbolic acid in water (1 in 40), but the steam-spray-producer is much more convenient and certain. The vessel for the carbolic acid must be filled with the 1 in 20 solution, which when mixed with the steam is reduced to about 1 in 30. The spray is undoubtedly a most efficient means of irrigation, but its routine use was founded upon an exaggerated idea of the part played by the air in contaminating wounds, and the uniformly good results obtained without employing it have led Lister to abandon its use. Furthermore, there are many positive objections to the use of the spray. It is inconvenient during the operation, wetting the Surgeon and obscuring his view, more especially if he is obliged to wear spectacles, which become quickly clouded by it; it may sometimes, in long operations, give him unpleasant symptoms of carbolic-acid poisoning, such as a general sense of illness, pain in the back, or even hæmaturia; it may depress the patient and add to shock by chilling the surface; and, lastly, the spray-apparatus is costly, difficult to keep in order, and inconveniently cumbersome to carry about in private practice.

During an operation it is convenient to have at hand a piece of linen rag soaked in an antiseptic solution, or, as it was termed by Lister, "a guard" with which to cover the whole wound during any temporary interruption in the operation, or any part of it upon which the operator is not engaged. The blankets over the parts around the surface exposed for the operation should be covered with mackintosh-sheeting, and over this towels wrung out in a 1 in 40 solution of carbolic acid should be spread, and the Surgeon should have within reach a basin of the lotion in which he can dip his hands at intervals.

In cases in which the operation-wound is complicated by the presence of old **sinuses**, such as are met with in many cases of joint-disease, these must be scraped out with a sharp spoon, and afterwards sponged with a solution of chloride of zinc (40 grains to 1 ounce). If the sinuses be numerous it is, perhaps, safer to wash the whole wound out with chloride of zinc lotion, the good effects of which were pointed out by Campbell De Morgan many years ago. Sinuses should not be injected before the operation, as there is some danger of rupturing their walls, and if the lotion should thus be injected into the cellular tissue the most extensive sloughing may result.

Reference has already been made to the important question of the drainage of wounds. It has been seen that the serous exudation can no doubt be much reduced by the uniform elastic pressure of a large cotton-wool dressing; and by perfect apposition of the surfaces no cavity can exist in the wound for the accumulation of discharges. This much-desired result cannot, however, be obtained with certainty, and more uniform success will be obtained by the use of drainage-tubes. It must also be remembered that the antiseptic applied to the raw surface increases the serous discharge during the first twenty-four hours. India-rubber tubes are, as a rule, the best, prepared and inserted in the same way as in the treatment of abscess (p. 261). One or more must be introduced in the very bottom of the wound, and the edges of the skin may then be brought together as closely as possible, a continuous suture being used if the Surgeon prefer it. The tubes must vary in size and number with the extent and nature of the wound, and must be brought to the surface at the most convenient and dependent parts. The tubes can in many cases be com-

pletely removed on the second day, without necessarily changing the whole dressing; often, however, they are needed for longer periods, and may be gradually shortened at successive dressings.

In order to avoid the necessity of removing the dressings to shorten or remove the tubes, Neuber invented absorbable tubes made from decalcified bone. Neuber's tubes were made from pieces of ox's bone drilled, and then decalcified. Macewen, who has made extensive use of absorbable tubes, prepares them much more simply, as follows: Take the tibiæ and femora of a fowl, scrape them clean, and place them in a 20 per cent. solution of hydrochloric acid till they are softened, then cut off the articular ends and clean out the medulla and endosteum; place them again in the acid for another day, and keep them ready for use in a 10 per cent. solution of carbolic acid in glycerine. They must be perforated in the same way as the india-rubber tubes. They act perfectly well in most cases, resisting absorption for about eight days, but they may collapse and thus fail to act, and, in some cases, they are not absorbed, and give rise to irritation. For the drainage of small wounds a few strands of catgut or horsehair will be found very efficient.

The wound having been closed with sutures, and drainage-tubes inserted, if necessary, the next step is to apply the antiseptic dressing. No organisms capable of setting up putrefaction or fermentative changes are supposed to have been left in an active state in the wound, and the small quantity of the antiseptic left between its surfaces quickly disappears, being partly absorbed and partly washed away by the serous discharge, and thus there is no source of irritation acting on the raw surfaces which could disturb the process of repair.

An **Antiseptic Dressing** should possess the following properties: 1. It must absorb the discharges readily, and, by the action of a trustworthy antiseptic agent, prevent their decomposition. 2. It must not itself act as a source of irritation by direct contact of the chemical antiseptic with the raw surfaces. 3. The antiseptic agent must be stored in the dressing in such a form that it is not too readily dissipated. 4. It must maintain rest and apposition of the surfaces. These objects may be attained by many different forms of dressing, only the more important of which can be described here.

Antiseptic dressings may be divided into two classes: first, those which, being themselves moist, prevent scabbing, or in which drying is prevented by a waterproof material covering the dressing; and, secondly, those in which the discharge is received in an absorbent material, and there allowed to dry. To this latter class belong the so-called "lasting dressings," which in many cases may be applied immediately after the infliction of the wound, and not removed, if all goes well, till healing is complete.

I. The **Carbolic Gauze Dressing** was invented by Lister, and was the first with which genuine aseptic results were obtained with any degree of certainty. The materials required are: 1st. The carbolic gauze. 2ndly. Some thick green oiled silk, coated with copal varnish, and covered with a thin layer of a mixture of dextrine and starch, so that when dipped in the carbolic lotion it may become uniformly wetted. This is called "protective oiled silk," or, shortly, the "protective." It is almost impermeable to carbolic acid, and is itself perfectly free from irritating properties, and thus, when applied to the wound, protects the edges from the direct action of the carbolic acid. 3rdly. Some thin waterproof sheeting, known in the trade as "hat-lining," or "pink jaconette".

The dressing may be applied with or without the spray. If the spray be not used the wound should be covered with a piece of linen rag, moistened with carbolic acid lotion (1 in 40), while the dressing is being prepared. This rag is commonly termed a "guard."

The dressing should be applied thus: a small piece of the "protective" dipped in the carbolic lotion is first applied to the wound, with a hole cut through it corresponding to the mouth of the drainage-tube. Over this is placed a double layer of gauze, dipped in the carbolic lotion and squeezed as dry as possible. This has been found to give additional safety, as the carbolic gauze often picks up pieces of dirt which are not disinfected by it in its dry state. Over the wet gauze are applied several dry layers, either smooth or crumpled up according to the form of the part. The quantity of this must be proportional to the amount of discharge that is expected to flow from the cavity. It must be arranged so as to fill up any natural hollows or irregularities of the part, so that the bandages may lie smoothly and evenly over it. The superficial dressing is then applied. This is composed of eight layers of carbolic gauze, between the two most superficial of which is placed a piece of "hat-lining." The object of this is to diffuse the discharge evenly throughout the whole dressing, and to prevent its soaking through at once opposite the wound. If no "hat-lining" is available, of course any other waterproof material will act equally well. The dressing, which must extend at least six or eight inches on each side of the opening, and furthest in that direction in which the discharge is expected to drain, is secured in its position by a bandage made of the antiseptic gauze, great care being taken to secure the edges. Lastly, elastic webbing from one inch to two inches in width according to circumstances, must be applied in such a way as to keep the edges of the dressing constantly in contact with the skin during any movement of the patient. In the case of a dressing on a limb, a single turn secured by a pin at the upper and lower end of the gauze is all that is required. In other situations the Surgeon must exercise his ingenuity in applying it in such a manner as to fasten the edges of the dressing securely on the part. It must, of course, not be applied so tightly in any case as to interfere with the circulation. The introduction of a few turns of elastic webbing in the application of the dressing is an important element in the success of the treatment.

The gauze dressing thus applied acts antiseptically in two ways: 1st, mechanically, by filtering any air that may pass through it, and thus excluding dust; and 2ndly, chemically, by slowly yielding up to the decomposable fluids which soak into it a sufficient quantity of carbolic acid to prevent putrefaction. Rest of the wound is favoured by the slight rigidity of the eight layers of gauze, by the gentle pressure of the bandage, and by the comparative infrequency of the dressings.

A carbolic gauze dressing must be changed at the end of the first twenty-four hours, or sometimes even before this if the discharge be very abundant. After this it must be carefully watched, and if any discharge appear at its edge it must again be changed. The carbolic acid being very volatile at the temperature of the body, the dressing gradually loses its antiseptic properties. About the third day, although the ordinary signs of putrefaction are absent, Watson Cheyne has shown that micrococci may make their appearance, and that their presence may be accompanied by some fermentative changes in the discharges which render them sour and somewhat irritating, and in this way

primary union may be interfered with and suppuration set up. Bacteria are found only if the dressing completely fails and putrefaction sets in. It would seem that the micrococci are less easily destroyed by carbolic acid than the bacteria, and consequently, as the dressing begins to lose its carbolic acid, partly by volatilisation and partly by solution in the discharges, they make their appearance. Ogston has shown that in the treatment of abscesses the development of micrococci can be prevented by more frequent dressings, and he is of opinion that the benefit derived from this is worth the extra trouble involved in dressing more frequently. It is probable that after the third day a carbolic gauze dressing becomes too weak to kill micrococci, and that by the end of a week it can no longer be regarded as antiseptic in any sense of the word. It is doubtful if at any time it is capable of destroying the spores of a bacillus.

In changing a carbolic acid dressing the spray may be used by those who prefer it, but equal safety can be obtained by irrigating and by covering the wound with a "guard" as much as possible when the dressing is off.

The carbolic gauze dressing has been shown by experience to give most satisfactory results, probably in every way equal to those obtained by any other method at present devised; but it has several disadvantages. The gauze, from being impregnated with paraffin, is not so absorbent as many other dressings, and if badly prepared it may cake into a hard mass, and altogether fail to absorb. It is not safe to use it as a lasting dressing. It occasionally, but rarely, irritates the skin, or causes symptoms of carbolic acid poisoning. It cannot be prepared by the Surgeon himself under ordinary circumstances, it gradually loses its virtues by keeping, and it is somewhat expensive. For these reasons it is less frequently used now than it was a few years ago, its place being taken to a very great extent by the mercurial dressings, or by some form of absorbent wool.

Eucalyptus Gauze (p. 211) and **Thymol Gauze** have been substituted for the carbolic in cases in which the latter caused irritation or symptoms of poisoning. They are applied in the same way as the carbolic gauze, and when quite freshly prepared, may be relied upon to prevent putrefaction; but they quickly lose their virtue, owing to the great volatility of the antiseptic.

The application of **various antiseptic lotions on lint** is a common mode of treatment, and is often attended with very good results, but if the discharge be abundant, decomposition is very apt to occur. Carbolic acid lotion (1 in 40) may be used in this way, but it requires very frequent changing, as the acid rapidly volatilises. It is, moreover, apt to irritate the wound and to interfere with union. Boric acid lint soaked in a concentrated solution of boric acid is less irritating, but it is not a very powerful antiseptic. The addition of one-fourth part of glycerine to the lotion prevents the lint from drying, but it is rather a painful application to a raw surface.

Oil containing some antiseptic in solution is one of the most ancient forms of dressing. Lint soaked in *carbolic oil* (1 in 10), applied so as to extend for some inches round the wound, may occasionally be useful in the absence of more convenient means, but it is not a very satisfactory dressing. It is a feeble antiseptic, and is apt to stick to the wound and become dry. It should be changed at least twice a day. Lint soaked in a mixture of one part of terebene to five parts of olive oil has given satisfactory results. All these

modes of treatment involve somewhat frequent dressing, and consequently some degree of disturbance of the wound.

II. The antiseptic dressings belonging to the second group are very numerous. They have the following points in common: First, the material used is more or less elastic, and is applied in large quantity, and secured by a bandage with some firmness, so as to exert a uniform pressure on the wound. This is the principle of Guérin's cotton-wool dressing already described (p. 322). Secondly, it is absorbent—the more so the better—so that the discharges shall diffuse themselves widely through it. Thirdly, it is impregnated with some efficient chemical antiseptic, which, becoming dissolved in the discharges, prevents their putrefaction. Fourthly, the dressing is not covered with any waterproof material, free evaporation being encouraged, so that the discharges, becoming dry, may thus certainly be prevented from decomposing, and the wound may heal as under a scab. Fifthly, if the object of the dressing is attained, and the discharges are completely absorbed and dried, the dressing is not changed until the wound is healed, unless it is necessary to do so in order to remove a drainage-tube or to take out deep stitches, provided that the patient is free from pain, and that the temperature remains at or near the normal standard. If the discharge be very abundant, so as to soak through the dressing, it of course becomes necessary to take it off and to reapply it, as under such circumstances the chemical antiseptic would be washed out, and decomposition would follow.

These dressings, by the uniform pressure they exert on the wound, ensure perfect coaptation of the surfaces, and tend to limit the exudation and facilitate drainage. They maintain the most perfect rest and avoid the disturbance of frequent dressing. They efficiently prevent putrefaction and infection, first by the chemical antiseptic they contain, secondly by drying the discharges, and thirdly by filtering the dust from any air that may circulate through them.

Dressings impregnated with Perchloride of Mercury are now very extensively employed, both in Europe and America. Any absorbent substance may in this way be made into an antiseptic dressing; sawdust, ashes, sand, wood-wool (p. 209), cotton-wool, linen rags, peat, moss, tow, jute, and many other substances have thus been made use of. This is indeed one of the greatest advantages of this form of dressing, and one which makes it specially applicable to military surgery. The antiseptic can be carried in the solid form, occupies but little space, and the Surgeon can seldom be placed in such a position that he cannot find some absorbent material with which to make his dressing.

A good example of this form of dressing is that adopted by Max Schede in the Hamburg Hospital. The material he uses is dried moss (sphagnum). This is picked over to free it from foreign matter, and then soaked for some hours in a solution of perchloride of mercury (1 in 500). It is then taken out and squeezed as dry as possible, and put into bags made of coarse muslin or gauze, which have been similarly treated. The bags are of all shapes and sizes, and about one inch in thickness. The cushions thus made are kept ready for use in a box lined with glass, and are not allowed to become quite dry. The wound having been closed and the drainage-tubes inserted, it is first covered with a thin layer of spun-glass, taken freshly from a 1 in 1000 solution of perchloride of mercury. Over this cushions of proper size and

shape are applied, so as to press the surfaces closely together, and over all a large cushion firmly secured by a bandage, which has also been disinfected with the sublimate solution. The early discharge washes the mercury out of the spun-glass, and then forms with it a collodion-like covering to the wound. The dressing is now allowed to dry, and if all goes well it is not moved till the seventh day, when the drainage-tube is removed. A second dressing is then applied, and left on till the wound is healed. If no drainage-tube has been inserted, one dressing only is required. According to Schede, this dressing very rarely irritates the skin. In impregnating cotton-wool he adds 1 part in 10 of glycerine to the mercurial solution. This increases the absorbing power of the wool. The results of this dressing have been very satisfactory. The antiseptic used is of sufficient strength to destroy not only the ordinary bacteria of putrefaction but also the spores of bacilli.

Sublimate Wood-wool is applied in the same way as the moss. The material is sold ready prepared. It is very absorbent and elastic, and makes an excellent dressing.

The Sal Alembroth Gauze and Wool (p. 209), introduced by Lister, have been largely used, and with good results in most cases. The gauze is elastic in mass and very absorbent. The dressing is thus applied: A piece of the gauze about four layers thick is dipped in a 1 in 2000 solution of perchloride. This washes out the sal alembroth, and leaves the gauze aseptic and quite free from irritating properties. This piece of gauze squeezed as dry as possible is applied next the wound. Over this a mass of the gauze some ten or twenty layers thick is applied, and over that again the wool. The whole is secured by a bandage. The wool, containing 2 per cent. of the salt, might irritate the skin if applied directly to it. The chief fault of the dressing is that it will not deal satisfactorily with large quantities of discharge. Owing to the great solubility of the sal alembroth it is readily washed away, and thus the dressing may fail as an antiseptic. If the discharge is small in amount and dries in the dressing, the result is all that can be desired.

The Double Cyanide Gauze (p. 209) has proved to be a most efficient dressing. It appears very rarely to produce irritation, and as the salt is very little soluble in the serous discharges, the dressing retains its antiseptic properties, even though the exudation be abundant. Lister recommends that the gauze should be sprinkled in bulk with 1 in 20 carbolic lotion, and kept wrapped in a sheet of hat-lining: the double salt being a powerful inhibitory agent, but only a feeble germicide, it is desirable in this way to destroy any organisms which may have gained access to the dry material. The thickness of gauze which is applied next the wound should be thoroughly wrung out in 1 in 20 carbolic solution; over this a mass of gauze treated as above described is placed, and over this again the salicylic or sal alembroth wool. Lister has found a cream made by moistening the dry cyanide powder with 1 in 20 carbolic acid solution very useful as an application to the skin around operation wounds situated in the neighbourhood of the anus, and in other positions where contamination of the wound from the surrounding parts is likely to occur.

Salicylic Wool, Salicylic Jute and Tow, Salicylic Silk, Iodoform Wool, are all applied in the same way as Guérin's cotton-wool dressing (p. 322), from which they differ only in the presence of the chemical anti-

septic. The salicylic and iodoform wools have been extensively used at University College Hospital during the last few years with the most satisfactory results, the wounds frequently healing under a single dressing. In operations in which a prolonged discharge of small amount may be expected, as in those for carious bone, it is often convenient to apply a piece of protective oiled silk over the wound to prevent scabbing, which might hinder the escape of any pus or serous fluid.

Carded Oakum, Tenax or Marine Lint, is a cheap antiseptic dressing, but it is not adapted for direct application to a wound, as it is too irritating. It may, however, be applied over one of the absorbent dressings above mentioned in order to economise the more expensive material.

Iodoform Treatment of Wounds was first introduced in Vienna in Billroth's wards, and has been much used there, according to Mosetig v. Moorhof, with the most satisfactory results. It is thus carried out. In the case of an operation the instruments may be disinfected with carbolic acid, and the sponges washed in some weak antiseptic solution, but this is not regarded as essential. The bleeding is arrested by catgut ligatures or torsion, and the wound cleaned. The raw surfaces are then freely dusted with finely powdered iodoform, drainage-tubes are inserted, and sutures applied in the usual way. The external dressing is composed of any absorbent material, such as gauze, wool, moss, &c., which may be impregnated with iodoform; but for prevention of sepsis reliance is placed rather on the iodoform in the wound than on that in the dressing. The advantages claimed for this treatment are, that it relieves pain by the anodyne action of the iodoform, that it is simple and efficient, and that the portable nature of the antiseptic makes it applicable in military surgery and in country practice. On the other hand, the antiseptic properties of iodoform have been denied; it has been said to fail entirely in the prevention of erysipelas, and to be liable when used in this way to give rise to iodoform poisoning. That iodoform does possess powerful antiseptic properties can hardly be doubted. In open wounds with loss of substance which cannot be treated by the methods before described, such as those left after removal of the tongue or after operations on the anus and rectum, its effect in preventing putrefaction is undoubted, and there is no more efficient antiseptic application. In excision of the tongue its use has reduced the death-rate to less than half of what it was. In such cases it is invaluable; but in clean wounds which can be accurately brought together, the iodoform can only be regarded as a foreign body, the introduction of which is not necessary. If not used in too great quantity, however, it does not interfere with primary union. Mosetig v. Moorhof states that he has very rarely observed any symptoms of poisoning. When it does occur he asserts that it is almost invariably due to one of three causes: First, to the simultaneous use of carbolic acid, which he believes interferes with the elimination of the iodoform by the kidney; secondly, to the use of excessive quantities, especially in fat subjects, iodoform being soluble in fats; and thirdly, to the presence of kidney disease or fatty heart. That it fails in the prevention of erysipelas is probably true. Its unpleasant smell is also no slight disadvantage. Taking everything into consideration, it may be said that the iodoform dressing is a reliable method of treating wounds, and in many cases is the most convenient that can be adopted.

The methods of treatment here recommended are all of established utility,

but numberless others have been tried and abandoned, or are at present being tested; and probably we have not yet discovered either the best antiseptic or the best mode of dressing. The tendency of the present time is in favour of some of the forms of lasting absorbent dressing impregnated with some efficient antiseptic. The Surgeon should make himself familiar with various methods of treatment, and employ that which seems most suitable to the case. It can rarely happen in civil practice that he is so situated as not to be able to adopt some efficient antiseptic treatment provided that he has mastered the principles upon which that treatment is founded.

Inflammation of Incised Wounds.—As before pointed out, a certain degree of inflammation is a necessary part of the healing of a wound by first intention. This should, however, be strictly limited to the tissues actually injured by the instrument which produced the wound, and should be very temporary in character. The simple traumatic inflammation, although pathologically of such great importance, is clinically so slightly marked by symptoms that it is frequently ignored; and when we say that a wound is "inflamed," we mean that some cause of inflammation other than the original injury has been introduced, which is causing the process to extend beyond the area actually injured by the cutting instrument. The causes of such inflammation have already been so fully discussed that we need only recapitulate them. They are predisposing and direct. The predisposing causes are the same as those of inflammation in general (see p. 172). The most important of these for wounds are: chronic alcoholism, insufficient and improper food, Bright's disease and diabetes, scurvy, &c., and local malnutrition from disease of the arteries. The direct causes are mechanical, as friction from want of rest, tension from tight stitches or from insufficient drainage, or pressure from tight bandaging; chemical, as the persistent contact with the raw surface of an irritating antiseptic or the products of putrefaction; and lastly, the true infective poisons, as those of erysipelas, pyæmia, hospital gangrene, &c. In the vast majority of cases in which a wound "inflames," the immediate cause is the presence of putrid discharges with insufficient drainage.

When a wound becomes "inflamed," the natural slight swelling and redness of the lips become exaggerated and extend further from the edges than they should, and instead of tending to subside after the first twenty-four hours, continue to extend to the third day or even later. The serous discharge, instead of ceasing on the second day, continues to flow and may increase considerably in quantity, and gradually by the third or fourth day assumes a distinctly puriform character. Instead of the perfect painlessness of a healthy wound, there is throbbing tensive pain with acute tenderness. The temperature rises to 101°—104° F. according to the size of the wound and the cause of the inflammation. In all cases the thermometer gives timely warning of the approach of this traumatic fever. The use of this instrument in surgical practice is attended with great advantage, as it often furnishes the earliest indication of the onset of some of the more serious sequelæ of wounds. The other symptoms of fever, hot skin, quick pulse, thirst, &c., are also present. In these circumstances all chance of union by the first intention is of course at an end; some or all of the sutures should immediately be removed to facilitate drainage and relieve tension, and strips of plaster may be used for support only and not for the purpose of maintaining contact of the surfaces in the hope of

obtaining union. If the wound is aseptic, which is rarely the case, the relief of tension alone may suffice to mitigate the symptoms; if the discharges are decomposing, some warm moist and antiseptic application should be used. The best of these is boric acid lint, or simple lint, three or four layers thick, moistened in a solution of boric acid, and applied as hot as the patient can bear it. The surface of the lint next the wound may be sprinkled with iodoform to render it more antiseptic. It must be covered with oiled silk and cotton-wool, and changed every four hours. A very efficient antiseptic fomentation may be made by wringing out a mass of salicylic wool in boiling water, and applying it in a similar way. Should these not be available, lint may be soaked in warm carbolic lotion (1 in 50); or a hot solution containing two grains of chloride of zinc to the ounce may be used. Simple warm-water dressings and poultices should be avoided, as they tend powerfully to encourage putrefaction. If the discharge is very abundant, the actual wound may be protected with a piece of lint dipped in carbolic oil (1 in 10), and the whole part surrounded with a mass of oakum wrung out of hot water and applied like a hot fomentation. If the wound be at all foul, the cavity must be syringed out at each dressing with some antiseptic solution, or a small quantity of iodoform may be powdered into it.

When the signs of acute inflammation have subsided, strips of lint dipped in lead lotion (Liq. Plumbi ℥ss, Sp. Rect. ʒi, Aq. Oj), and applied like straps to bring the surfaces together, will be found a very useful dressing. When granulations have sprung up and suppuration has fairly set in—that is to say, by about the tenth day—the granulating surfaces may, if possible, be brought together again by plasters and bandages, with a view to their uniting by "secondary adhesion." If this should be impossible, the raw surface becomes a "healthy granulating sore," and must be treated in accordance with the principles that guide us in the management of ulcerated surfaces (p. 274 *et seq.*). During the period of suppuration, the patient's strength must be well supported by proper diet, and his general health carefully attended to.

Inflammation may occur at a later period of the case, owing to a failure in the drainage and the accumulation of septic matter in the cavity, or to the infection of the wound with one of the specific infective processes, as hospital gangrene, erysipelas, wound-diphtheria, &c. Under these circumstances any union that may have taken place breaks down. The symptoms and treatment of these specific inflammations will be fully described in the chapters specially devoted to them. Inflammation from accumulation of decomposing discharges must be treated by partially opening up the wound and inserting drainage-tubes.

CONTUSED AND LACERATED WOUNDS.

These are wounds attended with more or less bruising or tearing about the edges and sides, and present every possible variety in degree from a cut on the shin to the crushing and laceration of a limb by a cannon-shot. They are commonly inflicted by blunt instruments, as by stones, bludgeons, &c. Lacerations by machinery, in which parts are torn off or crushed, the bites and gorings of animals, and gun-shot injuries of all kinds, come under this denomination.

CHARACTERS.—Whatever the mode of infliction, these wounds present certain characters in common. Their lips are irregular and torn, less gaping than incised wounds, and surrounded by more or less ecchymosis. There

is usually but little hæmorrhage, and the pain is of an aching or dull character.

They differ from incised wounds in the fact that a distinct layer of tissue injured by the instrument which inflicted the wound is actually killed, and, if of any thickness, must be separated and thrown off, as a slough, before union can take place. No sharp line can, however, be drawn between the different kinds of wounds. Some wounds, which from the mode of infliction and their appearance would be classed as contused, are in reality capable of uniting by first intention, the layer of dead tissue being either microscopic or wanting. This is especially the case in vascular parts, such as the scalp and face. In other cases, a wound apparently similar may slough for a considerable distance on each side.

In consequence of the sloughy state of their lips and sides, *the majority of contused and lacerated wounds unite by the second intention.*

Contused and lacerated wounds present peculiarities according to the mode of their infliction. When they are produced by the bite of a large animal, the part injured becomes very painful, and inflames extensively; the wound being lacerated, much contused, and often penetrating deeply. It sloughs in consequence of the pressure to which it has been subjected, and of the shaking and tearing of the part by the animal. When inflicted by the tusk or horn of an animal, the wound is extensively lacerated rather than contused, and often partakes of the nature of a punctured wound.

When a part of the body is torn off, the wound presents peculiar characters: which differ, however, according as the separation is effected at the part struck or seized, or at a distance from it. In the first case—as when an arm is caught in a machine of any kind and crushed or torn off—the stump presents a ragged surface, the skin being stripped away higher than the other parts, the tendons hanging out, and the bellies of the muscles that are torn across being swollen, protruding, and apparently constricted by the lacerated integument. A most important condition in such wounds is the state of the vessels: these are separated lower down than the other parts, for, being elastic, they elongate and pull out before they give way. There may be no hæmorrhage, because the inner and middle coats of the artery, breaking off short, retract and contract to a small aperture, and allow the external coat to be dragged down and twisted over them, in such a way as to offer a complete barrier to the escape of blood. The bone is crushed off at the end of the conical stump, of which it forms the apex, and is often split up to the next joint above.

Occasionally, when parts are pulled off, they are separated at a distance from the point seized. Thus, fingers that have been torn off by machinery have their extensor and flexor tendons separated higher up, at their junction with the belly of the muscle, and not at the part seized; the tendon being drawn out of its sheath, and hanging on to the separated end in a ribbon-like manner.

This peculiar tearing away of the tendon from its attachment to the muscle and not across the line of laceration of the limb, was described by several writers in the Memoirs of the Academy of Surgery of Paris in the middle of the last century, and the accompanying figures, 100, 101, taken from Morand's paper, illustrate well this very singular injury. In railway accidents, when a train has passed over a limb without completely separating it, the muscles may be found detached from their origins.

PROGRESS.—In the progress of a contused or lacerated wound there are two distinct periods: 1, the separation of the slough produced by the contusion; 2, the repair by granulation of the cavity left. The process by which a slough is separated has already been described on p. 270, and that of repair by granulation on p. 293.

The **Extent of the Slough** depends not only upon the extent and severity, but also upon the situation, of the injury. If the parts around the wound be much bruised, superficial sloughing to a great extent may occur; if the wound be deep though not extensive, there will always be danger of deep suppuration and burrowing of matter, leading to troublesome sloughing, and in

Fig. 100.—Ring Finger torn off, with deep Flexor Tendon.

Fig. 101.—Thumb torn off, with Tendon attached.

some cases to secondary hæmorrhage. Those wounds that are situated immediately over bony points—as the shin and elbow—are especially tedious, as the slough frequently implicates the fasciæ, and therefore separates slowly. The scalp, owing to its great vascularity, has less tendency to slough than any other part of the cutaneous surface. In all cases of contused and lacerated wounds, in which sloughing and suppuration follow the injury, there is a greater liability to the supervention of infective inflammations than in clean-cut incised wounds. In most contused wounds the extent of the slough is, to a certain extent, influenced by treatment. On each side of the wound, beyond the layer of tissue actually killed, there is an area, frequently of considerable extent, in which the tissues are damaged and hovering between life and death, and any additional irritation will suffice to extinguish the remains

of vitality. Thus, if such a wound be tightly sewn up, the tension of the stitches will inevitably cause sloughing in the whole doubtful area. The irritation of decomposing discharges is another most potent cause of extension of the area of death, and in fact, it is in such wounds, much more than in clean-cut incisions, that the immense benefit of some form of antiseptic treatment is most clearly recognised. In primary amputations for contused and lacerated wounds it frequently happens that the incisions pass through this doubtful area, and the extra injury thus done determines the death of the part, even though, at the time, it may have appeared to be uninjured.

The chief danger to be apprehended in wounds of this description is the supervention of **Gangrene**, which may occur in one of three ways :—

1. In some cases the violence done to the part is so great as directly to kill its whole substance. Thus, if a limb be crushed to pulp by machinery, or by the passage of a heavy waggon over it, the part may speedily become gangrenous. This is a local traumatic mortification, evincing no disposition to spread beyond the part injured, but being bounded by a line of demarcation along which it will separate. It is not always easy to distinguish this direct form of gangrene from such discoloration and disorganisation of a limb as are still compatible with life. In all cases of doubt the Surgeon must wait, and a very short time—a few hours—will be sufficient to declare whether the vitality of the part can be maintained or not. In cases of great doubt an incision might be made into the part, and the true state of things thus ascertained ; but this should not be done if it can possibly be avoided, and if undertaken the most rigid antiseptic treatment should be adopted, as the decomposition of the extravasated blood in the tissues of the bruised part would inevitably extinguish such vitality as remained. In many cases it is a good plan to disinfect the part carefully, dress it antiseptically, and wait for the line of demarcation between the dead and living parts to form before undertaking any operation.

2. The injury may damage the great vessels of a limb to such an extent as to interrupt the circulation ; gangrene being thus induced in the parts supplied by them. This form of gangrene we shall have occasion to treat of when speaking of Injuries of the Arteries.

3. The true "spreading gangrene," the most fatal variety of mortification, is most commonly the result of contused or lacerated wounds. This is a most acute infective inflammation, terminating rapidly in gangrene, and will be described with the other infective processes occurring in wounds.

Treatment of Contused and Lacerated Wounds.—In the treatment of the slighter form of these injuries, we must bear in mind the occurrence of the two distinct periods : 1, that of the separation of the sloughs ; and 2, that of granulation. There is also in all injuries of this description a special tendency to the occurrence of erysipelas and allied diseases.

Care must be taken to clean the parts thoroughly from foreign bodies that are frequently impacted or ground into them. However contused and torn a flap of skin may be, it should never be removed, provided it maintain any attachment to the neighbouring tissues, but should be replaced on the chance of its vitality being preserved. If it live, as it will often do, especially about the scalp and face, under apparently the most discouraging circumstances, much will be gained ; if it slough, no harm can result from the attempt to preserve it. There are cases on record in which parts that have been even

completely separated have become attached, by being immediately reapplied to the surface from which they had been torn or cut. Whether or not this be actually the case in contused or lacerated wounds, it is at all events certain that a very small tongue of skin is sufficient to maintain the vitality of a part. This we see exemplified in the operation for the restoration of a lost nose; and cases have occurred to me in which the nose, retained only by a portion of one ala, has readily united on being replaced; so likewise, in bad cases of compound dislocation of the fingers, the part has been saved, though merely attached by a narrow bridge of skin. After a part has been replaced in this way, it should be retained *in situ* by a few points of interrupted suture, and dressed with boric acid ointment spread on thin muslin, or some other unirritating antiseptic application. In lacerated wounds opening into the mouth or nose a piece of lint soaked in collodion may be applied externally, as there will be ample drainage from the internal aspect of the wound. The sutures in these cases must be left in for a somewhat longer time than usual, until good union has resulted. The hæmorrhage, as before mentioned, is as a rule easily controlled; position, application of cold, and the subsequent bandaging, being sufficient in the majority of cases. When, however, the blood is bright-coloured and continues to drip from the wound, a vessel of some size has been divided: this should be searched for, and secured by torsion or ligature.

Ordinary cases of contused or lacerated wounds, whether superficially extensive or deep, are best treated on exactly the same principles as incised wounds. Although we can rarely hope for union by the first intention, *rest* is necessary to favour such union as may occur, and to relieve the patient from pain; *drainage* requires special attention, as the injury being more severe, the early exudation from the wound will be more abundant; and the *prevention of decomposition* becomes of the greatest importance, as the irritation of putrid matter might extinguish the vitality in tissues which would otherwise have recovered. In treating such wounds exactly the same proceedings must be adopted as in an accidental incised wound (p. 315 *et seq.*), but greater care is necessary in cleaning the wound with the lotion on account of its irregular nature. If there is no chance of union at any part, it is better not to insert stitches; for, as it must heal by granulation after the separation of the sloughs, nothing can be gained by their use, and they may seriously impede the drainage. There is no class of wounds in which the benefits of antiseptic treatment are more marked than in these. Under its use the sloughs may separate with scarcely any suppuration, and the inflammation accompanying the process may not extend a tenth of an inch beyond the dead tissue; and all this may occur without any general febrile disturbance. In contused and lacerated wounds of the hand or foot, in which the parts are often extremely dirty, it is safer to put the limb in a bath of carbolic acid lotion (1 in 40) for about a quarter of an hour before applying the dressing in order to ensure thorough asepticity.

Should the antiseptic dressing fail, or should the case not be seen till decomposition has commenced, *Disinfectants* must be freely used. The wounds must be washed or syringed out several times a day with weak solutions of perchloride of mercury, 1 in 5000, chloride of zinc, permanganate of potash, or carbolic acid. In this way sloughs and decomposing pus may be removed, and the tendency to local inflammation of a spreading character,

and to the development of pyæmia, averted. There is no more fertile cause of these disastrous effects than the retention of fœtid decomposing pus in the areolar tissue of a contused wound. The separation of the sloughs must be facilitated by the application of warmth and moisture, which serves also to subdue local inflammation. Boric acid lint, moistened with hot boric lotion and covered with oiled silk and cotton-wool, is one of the best of all applications. It is most efficient, easily applied, and perfectly clean. If the wound becomes foul, the surface may be sprinkled with iodoform in crystals. Carded oakum, moistened in hot water and covered with oiled silk, answers the purpose tolerably well ; it is cheap and antiseptic, but dirties the skin. Linseed meal poultices should always be avoided ; they encourage putrefaction and greatly increase the suppuration, the evil they do in this way more than counterbalancing any comfort the patient may experience from their application.

About the period at which the slough begins to be loosened, there is danger of the occurrence of **hæmorrhage** if a large artery have been implicated in the injury. When hæmorrhage occurs in this way, it usually sets in from the sixth to the twelfth day, and may be speedily fatal ; the treatment should be the same as that to be hereafter described for secondary hæmorrhage after ligature of an artery in its continuity. After the sloughs have separated, an ulcer is left, which must be treated on general principles.

Amputation.—In the more severe cases of contused or lacerated wounds, any attempt to save the part may be hopeless, and the patient's only chance lies in *amputation*. In determining the expediency of operation, two questions present themselves : 1, the nature of the cases in which amputation should be performed ; and, 2, the time at which it should be done, whether immediately after the infliction of the injury, or subsequently.

It is difficult to lay down more than very general rules as to the *kind of cases that require amputation*, much depending on the age, constitution, and previous habits of the patient. In any case the Surgeon should be careful not to condemn a limb which there seems to be a fair chance of saving.

As a general rule, severe injuries are more readily recovered from in the young than in the old, their vitality being greater, and their tendency to consecutive diseases less. Much will depend upon the habits of the patient, or upon the existence of visceral disease at the time of the injury. In persons who have been free livers, and who have that peculiar irritability of system conjoined with deficient power commonly observed in such subjects, and more especially if there be disease of the liver or kidneys, contused and lacerated wounds are apt to be followed by the worst forms of erysipelas and gangrenous cellulitis, and thus to be speedily fatal. Injuries of the upper extremity are less serious than those of the lower, its supply of blood being proportionately greater. In some contused wounds of the arm and hand, as in bad lacerations with fracture about the shoulder, elbow, or metacarpus, resection of the injured part may be performed instead of amputation of the limb.

Though there must be in many cases a doubt as to the necessity of amputation, there are certain conditions in which the Surgeon need never hesitate to perform this operation, as the only chance of saving the patient's life. The following are cases in which the limb should be amputated, either with the view of preventing the occurrence of gangrene, or in order to remove a mortified part, and thus save the life of the patient at the expense of the injured limb:

1. If a limb have been torn off by machinery, carried away by a cannon shot, or cut off by the passage of a railway-train over it, the irregular and conical stump should be amputated.

2. If the whole thickness of a limb—the soft parts and the bones—be thoroughly disorganised and crushed, it must be removed.

3. If the soft parts be extensively stripped from the bones, though these be entire, so much sloughing will ensue as to leave a useless limb, and amputation should be performed. It is in these cases that it is often especially difficult to estimate the amount of injury that cannot be recovered from, this depending much upon the age and constitution of the patient. In such cases the life may be lost in trying to save the limb. I have more than once had reason to regret having attempted to save limbs injured in this way; and I believe that, if the skin of the lower extremity be extensively torn down and the muscles much lacerated, so as to slough away, there is but little chance for the patient —unless he be young, and of a remarkably sound constitution—except in amputation. In the upper extremity it is different; there, recovery may take place under the most adverse circumstances. In all parts the dangers of attempting to save a limb have been greatly lessened by the antiseptic treatment. If decomposition of the sloughing tissues can be prevented, there will be little fever and but slight local inflammation, and the risk of pyæmia and erysipelas or other infective processes is scarcely appreciable. Supposing the attempt to save a useful limb to fail, if the antiseptic treatment is successful the chances of recovery are in no way impaired by the delay in amputating.

4. So also, if the knee be largely opened, with laceration of the soft parts and perhaps fracture of the contiguous bones, the limb must be amputated. Corresponding injuries of the ankle, shoulder, and elbow joints may, as has already been stated, admit of resection rather than amputation. In these cases also, the antiseptic treatment is an important aid in saving a limb, for if decomposition can be prevented, the mere fact that a joint is opened adds but little to the gravity of the case.

5. Bad crushes of the foot have a great tendency to run into gangrene, and hence require amputation. In the hand, on the contrary, very extensive injuries are often recovered from without this operation being necessary; and in many cases partial resection may be substituted for it.

6. In those cases in which a large artery, as the femoral, is lacerated at the same time that the soft parts are extensively injured, and the bone fractured, amputation is required in order to prevent the occurrence of gangrene. In the more local form of traumatic gangrene, in which the disease is confined to the part directly crushed and injured, no good can come of delay, and amputation should be performed as soon as mortification has declared itself; and the limb must be removed at a sufficient distance from the seat of mischief. When the mortification results indirectly from injury of the vessels, the limb should also be immediately removed in a line with the wound, unless this be too high up; then the most favourable point must be chosen, as will hereafter be explained. Amputation in these circumstances is by no means a very unfavourable operation (and it is one that I have several times successfully performed), provided it be done sufficiently early, before the constitution becomes poisoned by the absorption of septic matters from the gangrenous tissues. It is scarcely necessary to warn the Surgeon to be certain of the existence of gangrene before he

operates; and also that it be not a mere limited slough, but sufficiently extensive to jeopardise the patient's life.

7. In cases in which spreading gangrene attacks the wound early, amputation is the only hope of saving the patient.

The question as to the *period* at which amputation should be performed in contused wounds from gun-shot will be considered later on. It may be generally stated, that the sooner a condemned limb is taken off, the less is the suffering, and the better the chance of recovery of the patient; and that, consequently, primary amputation should be practised in these cases. By reference to the tables on pp. 89, 90, it will be seen that, although the average mortality for all primary operations is less than the average mortality for all secondary operations, yet primary amputation through the thigh is more fatal than secondary amputation in the same region. Notwithstanding this, it is absolutely necessary in many cases to remove the injured limb within the first twenty-four hours. The higher rate of mortality of primary thigh-amputations may be due chiefly to the greater severity of the injuries that manifestly require immediate operation than of those in which it is thought justifiable to attempt to save a limb; and certainly, of the two alternatives—of leaving a badly crushed and mangled limb until suppuration has set in, and thus exposing the patient to all the risks of gangrene, erysipelas, pyæmia, &c., or removing it at once—the latter is the one attended with least danger to the patient.

A limb is sometimes so hopelessly crushed that any attempt at its preservation must be useless; whilst at the same time the patient is so severely injured internally, or is so prostrated by shock, that amputation as a formal operation would be as useless as it would be unjustifiable, the patient having at most but a few hours to live. In these circumstances the best thing that can be done is to put on a tourniquet, partly to check hæmorrhage, and partly to restrain the painful quivering of the muscles, and to wrap up the maimed limb. Should the limb have been nearly detached—merely hanging on by shreds of the lacerated muscles—these may be divided, and its removal thus effected without additional shock or suffering.

Brush-Burn.—This is a peculiar injury occasioned by rapid and severe friction of the surface of the body, so that the skin becomes abraded and the subjacent tissues somewhat contused. It is not unfrequently produced in the manufacturing districts, by the surface of the body coming into contact with straps or portions of machinery in rapid motion. It has also been known to occur in consequence of a person slipping and sliding rapidly down a long and steep Alpine snow-slope. In this injury the integument is, as it were, ground off, and the areolar and aponeurotic structures converted into an eschar.

The *Treatment* presents nothing special, but should be conducted on ordinary principles. The separation of the eschars must be facilitated by moist antiseptic applications, and the resulting sores will heal by granulation.

STABS AND PUNCTURED WOUNDS.

These wounds, made by narrow sharp-pointed instruments, vary greatly in extent, from the prick of a needle in the finger to a sword-thrust through the body. Not unfrequently punctured wounds are somewhat contused, being made by a triangular or wedge-like weapon, as a bayonet or lance-blade

When deep, they are of a most dangerous character—wounding blood-vessels, traversing the great cavities, and injuring the contained viscera. A punctured wound is extremely difficult to drain, the external orifice being very small in proportion to the area of the surface. Thus, if a narrow weapon half an inch in width were thrust into the thigh for a depth of six inches, the area of the two surfaces of the wound would be six square inches, while the external opening would be only half an inch in length. The small external opening is easily choked by a clot of blood, and is frequently injudiciously closed by the Surgeon. The whole track becomes distended with the blood or serous exudation, and unless means are taken to prevent it, decomposition sets in, followed by inflammation and suppuration extending deeply into the injured part. In consequence of this, combined with the insufficient exit for the discharges, the pus may burrow deeply, large collections of septic matter may form, and severe constitutional disturbance is the necessary result.

Treatment.—In the treatment of punctured wounds, the principal points are to arrest the hæmorrhage, and to facilitate union.

The hæmorrhage must be arrested by pressure properly applied by means of compresses or pads, so as to approximate the sides of the puncture ; by the application of cold ; or by cutting down on the injured vessel if it be a large one, and ligaturing above and below the perforation in it.

In many cases of severe punctured wound suppuration and union by second intention will take place in consequence of the great difficulty in drainage. In order to obtain early union, the cavity should be washed out with carbolic acid lotion (1 in 40) or some other antiseptic, by means of an india-rubber tube on the end of a syringe. Care must be taken that there is plenty of room for the fluid injected to flow out rapidly, otherwise the spaces of the areolar tissue will become widely distended with the antiseptic solution ; all superfluous lotion is then squeezed out, and a drainage-tube inserted deeply into the wound. This may be considerably shortened after twenty-four hours, and gradually diminished day by day till it can be safely removed. The external application should be one of the forms of absorbent antiseptic dressing. On no account should a punctured wound be closed by collodion or any other occlusive application. The small size of the external opening is apt to make the Surgeon forget the real extent of the injury. As the tube is shortened, the coalescence of the sides of the wound may be encouraged by properly applied compresses and bandages. The deep inflammation that so often follows these wounds is due solely to insufficient drainage and decomposition, and no treatment but the prevention of these conditions will exclude it. In former days, when duels with the small sword were of frequent occurrence, persons called "suckers," who were often the drummers of a regiment, were employed to attend the wounded combatants. Their treatment, which was conducted with a certain degree of mystery, consisted in sucking the wound till all blood ceased to flow, and then applying a pellet of chewed paper or a piece of wet linen to the orifice; in this way it would appear that many sword-thrusts traversing the limbs were healed in a few days. The process of suction cleared the wound thoroughly of all blood, and, drawing the sides into close apposition, placed the parts in the most favourable condition possible for union by primary adhesion. This practice might, perhaps, in many cases be advantageously imitated in the present day by means of a cupping-glass and syringe.

Amongst the varieties of punctured wounds that are most commonly met with in ordinary practice are those which are occasioned by needles penetrating into, and breaking off in the body. These accidents occur chiefly in the fingers and feet, and about the nates ; and, though trivial, are often extremely troublesome, both to the Surgeon and to the patient. When the Surgeon is called shortly after the occurrence of the accident, he must endeavour to remove the fragment left behind, by cutting down upon it. In doing this he will be guided by the situation of the puncture, and by the seat of the pain, and sometimes by feeling the point projecting under the skin. In many cases this is a sufficiently simple proceeding ; in others, however, a deep and troublesome dissection may be required, especially when the fragment of needle gets into or under the sheath of a tendon. I have had occasion to undertake somewhat troublesome dissections for the removal of needles ; in one case between the biceps tendon and the brachial artery, and in another in close proximity to the ulnar artery in the wrist. For the purpose of extracting needles, thorns, splinters of wood, and other foreign bodies of small size and pointed shape lying in narrow wounds, forceps with very fine but strong and

Fig. 102.—Indian Arrow penetrating temporal bone. Medical Department, United States Army.

well-serrated points will be found useful. One of the most dangerous situations for a needle to penetrate is the anterior part of the knee-joint, lodging in the head of the tibia or in the patella, and breaking off short. In such cases the fragment should be dissected out at once, the strictest antiseptic precautions being adopted to prevent inflammation of the joint. The limb must then be fixed on a splint. I have known the most acute suppuration of the knee ensue in consequence of a portion of needle having been allowed to remain embedded in the joint. The patient's life was in imminent peril, but recovery ultimately took place with ankylosis of the joint.

The movements of the part in which the needle is lodged tend to make it travel in the direction of its point, and consequently in many cases if it has been lodged for some days the Surgeon will fail in his endeavours to extract it. Unless, therefore, the indications of its presence be very clear, I think the wiser course would be to leave it undisturbed, and to trust to nature for its expulsion, as it can seldom be found when sought for, and, indeed, may not exist, although supposed to be present. The following plan of ascertaining whether a portion of needle be really impacted has been suggested by Marshall,

and successfully carried into practice by Littlewood of Leeds. A powerful magnet is to be held upon the part for a quarter of an hour, so as to magnetize the fragment; a finely hung polarized needle should then be suspended over it, when, if any iron is present, deflection will ensue.

When a fish-hook, crochet-needle, or other barbed instrument has been run into the flesh, no attempt should be made to withdraw it through the aperture by which it entered, but the point should be pushed on so as to emerge through the skin, the shank then divided with pliers, and the barbed end drawn out.

Arrow-Wounds occasionally fall under the observation of the military or colonial Surgeon as the result of injuries received in conflict with barbarous races. They differ only in one essential respect from penetrating punctured wounds made by knife-stabs and sword-thrusts, viz., that the arrow-head will remain impacted in the tissues it has penetrated (Fig. 102). The force with which an arrow may be shot is well illustrated in the accompanying figures taken from preparations in the Army Museum at Washington. The arrow shot from the bow of a North American Indian has been known to traverse the body of a buffalo and penetrate the under surface of its scapula, as shown by a preparation in the same Museum.

The extraction of an arrow is usually attended with little difficulty. But if barbed, or if the shaft becomes detached from the head, special precautions have to be taken. With the view of safely effecting its removal, the "snares" figured below (Fig. 104) have been devised.

Fig. 102.—Buffalo Rib pierced by Indian Arrow. (Med. Dep. U. S. Army).

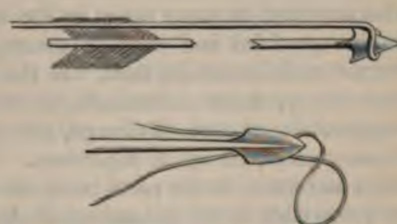

Fig. 104.—Bill's Snare for Extraction of Arrow-Heads.

CHAPTER X.

GUN-SHOT WOUNDS.

GUN-SHOT wounds, though comparatively rare in civil practice in this country, are yet sufficiently frequent to render an acquaintance with them indispensable to the general Surgeon. To the military Surgeon the study of them is necessarily one of the greatest importance; and to him I would specially recommend the perusal of the works of Longmore, Stromeyer, Esmarch, and Fischer, who have had unusual opportunities of studying these injuries on the field of battle. The works of Guthrie, Hennen, and Larrey, whose experience was gained in the wars in the early part of the present century, are well worthy of study, and much that is interesting will be found also in the writings of Ambroise Paré, Wiseman, and John Hunter.

In the following observations I shall confine myself to such a general discussion of the subject as may be useful to the civil Surgeon.

Gun-shot injuries constitute a species of contused and lacerated wounds, often partaking also of the nature of punctured wounds in the disproportion between the subcutaneous mischief and the external aperture. They are characterized in many cases by the extensive injury inflicted on the tissues, both superficial and deep, in consequence of which the wounds may prove immediately or rapidly fatal. If the sufferer survive the immediate effects of the injury, acute inflammation with much pain and tension, deep-seated suppuration, profuse discharge, and other serious and very protracted after-consequences, are apt to supervene. These peculiarities have at different times been attributed to the parts being burnt by the ball, to the poisonous nature of projectiles, to the generation of electricity in the bullet during its passage through the air, or by its friction against the barrel. All these opinions, however, have been shown to be erroneous; and every peculiarity of these injuries can be accounted for by the bluntness of the missile, the force with which it is driven, and by the insufficient exit for the decomposing discharges that necessarily accumulate in the track of the bullet, unless septic processes can be prevented by the efficient use of antiseptics. John Bell has pithily remarked, "there is a peculiarity, but no mystery, in gun-shot wounds."

CHARACTERS.—Gun-shot wounds vary greatly according to the nature of the Projectiles, the force with which they are driven, and the direction in which they strike.

Nature and Force of Projectile.—Injuries of a serious character may be inflicted by *weapons charged only with powder*. These may arise from the mere concussion of the explosion; thus a pistol charged with powder, and discharged with the muzzle resting against the chest of a man, has been known to kill by concussing the heart. In other cases, a portion of the unexploded powder may be driven into the skin by that which is exploded behind it. In this way, very disfiguring marks are sometimes made on the face by the powder lodging in the skin. The force of the explosion will sometimes

produce serious lacerations. Suicides occasionally forget to put a bullet into the pistol, and firing into their mouths, blow open the cheeks, and injure the pharynx and glottis by the explosive force. Some years ago, a man was brought to University College Hospital, who had discharged some powder from the tube of an Italian iron into his mouth, and he died in consequence of the injuries he received. In another case, a man died, on the fifth day after firing a pistol into his mouth, of asphyxia, occasioned by sloughing of the pharynx and inflammation of the glottis and larynx, consequent on the scorch of the explosion.

Wadding and Soft Materials, as pieces of clothing, will occasionally inflict serious wounds by the force with which they are driven into the body. These injuries often happen on the stage, at reviews, fairs, &c. Taylor relates several instances of the kind :—one of a girl killed by a gun charged with paper pellets ; also, one of a man who was killed by a kid glove fired from a blunderbuss. Dupuytren mentions a case in which a fowling-piece loaded with powder and a paper wad, and fired at a distance of two or three feet, killed a man by piercing the abdomen with a round hole.

Small Shot often inflict serious injuries, and these are most commonly met with in civil practice. If the person wounded be within a few feet of the muzzle of the gun, a terribly lacerated wound, even worse than that occasioned by a bullet, will be inflicted ; for the shot, not being scattered, are driven through the body in a compact mass, and tear the tissues to a great extent. The compactness of a charge of shot when striking close to the muzzle of the gun may be very remarkable, making a wound like that of a bullet. A lad was admitted into University College Hospital under my care, who had accidentally shot himself. The whole charge had passed from before backwards between the skin of the inner side of the arm and the brachial vessels and the accompanying nerves, leaving a bridge of skin about three inches in width and the vessels and nerves uninjured, the triceps, however, being torn. The patient made an excellent recovery.

When shot scatter as they fly, they produce at a greater distance a less serious injury, usually lodging in the subcutaneous areolar tissue, where they may remain permanently without causing any trouble ; or they may give rise to suppuration. Penetrating an important part, shot may cause serious or fatal results ; thus, a single shot penetrating the eyeball will destroy vision ; or, lodging in the heart or in the femoral vein or other large vessel, may give rise to rapidly fatal results. A patient was once brought to University College Hospital, who had fired a pocket-pistol loaded with small shot into his mouth ; after death, the shot were found deeply lodged in the vertebral column.

Splinters of metal, wood, or stone, carried by the force of an explosion, as in blasting and mining operations, may inflict grave injuries. These latter inflict perhaps the worst forms of injury from bodies propelled by explosive force that are met with in civil practice. In siege operations much injury also is often inflicted by the splinters from parapets, or by the forcible throwing up of gravel and small stones by the explosion of shells. In naval actions, too, the force with which splinters of wood are driven, when struck and scattered by cannon-shot, is often so great as to inflict the most serious and even fatal mischief. A particular form of injury, formerly common in civil practice, was a wound of the eyeball by the splintering of faulty percussion-

caps. Wounds of the face and other parts by the splashes or splinters of bullets from the surface of targets, are of common occurrence among markers at rifle-ranges.

Slugs are irregular bits of lead of no definite form or size. They produce wounds more ragged than small shot, but, unless fired at very short range, they seldom penetrate deeply. The experience of the Ashantee War, in which the natives used slugs almost exclusively, showed that the proportion of severe to slight wounds was very small, the projectile not having sufficient power to break a large bone.

Bullets occasion more serious wounds, lacerating soft parts, fracturing and crushing bones, tearing asunder vessels and nerves, perforating the viscera and occasionally cutting off parts, as a finger, the nose, or an ear.

Fig. 105.—Perforation of Right Femur by bullet. Longitudinal Splitting of Bone. (United States Army Museum.)

The introduction of rifled fire-arms into warfare greatly increased the destructive effects of bullets. On the bones especially, the modern *conico-cylindrical bullet* often produces the most destructive effects; not only comminuting the part struck, but often by its wedge-like action splitting up the shaft of the bone in fissures many inches long, leading into contiguous joints (Fig. 105).

The bullet of the new Lee-Metford magazine rifle is small in diameter, and has a very high velocity. Thus the diameter of the Snider bullet is 0·577 in., that of the Martini 0·45 in., and that of the Lee-Metford 0·303 in., whilst the muzzle velocities are 1240, 1315, and 1800 feet per second respectively. The outer sheath of the new projectile is composed of a very hard combination of copper and nickel, which prevents the breaking-up of the bullet at the moment of impaction, and thus may tend to diminish the almost "explosive" effects of the old lead bullets.

Direction.—In the majority of cases, a bullet traverses the part struck, and the wound has two apertures, one of entry, the other of exit; occasionally it happens, however, that in consequence of the ball being spent, or of the oblique direction with which the ball strikes the part, it rebounds or glances off, leaving merely a contusion or dent. In other cases there is only one aperture; and here the bullet, partly spent, has probably lodged in the soft tissues, or in a bone, or in one of the cavities of the body. It sometimes happens, however, that the ball drops out through the aperture at which it entered, as when a spent ball strikes a rib; or that it carries a pouch of clothing before it, which enables the Surgeon to withdraw it. One bullet may make even more than two apertures; thus a round ball has been known to split against the sharp edge of the tibia, and to have one aperture of entry and two of exit; or it may pass through both thighs or both calves,

1. 2. 3.

Fig. 106.—Rifle bullets. 1, Snider; 2, Martini-Henry; 3, Lee-Metford.

and thus occasion four apertures; and cases have been recorded in which five wounds even have been made in the same person by one bullet.

The direction of the openings is often of importance from a medico-legal as well as from a surgical point of view. Thus, Sir Astley Cooper, by attending to this point in a case of murder, ascertained that the fatal shot must have been fired by a left-handed man; and this led to the detection of the criminal. These apertures, though usually opposite to one another when a ball passes right through a part, are not always so, the bullet being deflected by the bones, or by the elasticity of the skin, so that the two apertures do not correspond. Thus a spherical bullet has been known to strike a rib and then to be deflected, running under the skin to the opposite side of the body; again, striking one temple, a bullet has been carried under the scalp to the other side of the head, where it has passed out; thus it might appear that important cavities had been penetrated, when in reality they had not been wounded.

The **Apertures of Entry and of Exit,** made by a bullet, deserve attentive consideration. With the *round-bullet* projected at a comparatively low velocity, the difference in the two apertures was usually very obvious, and is well shewn in Figs. 107 and 108. The aperture of entry was small, circular in shape, less than the diameter of the ball in breadth, the edges being inverted and ecchymosed. The aperture of exit was commonly large, somewhat everted, and irregular, admitting two or even three fingers freely.

Fig. 107.—Gun-shot Wound. Aperture of Entry.

Fig. 108.—Gun-shot Wound. Aperture of Exit.

Of the various explanations which have been suggested for these differences in the character of the apertures, that given by Guthrie is undoubtedly the most important. The loss of momentum sustained by the bullet as it traverses the tissues is viewed by Guthrie as the chief factor in determining the character of the aperture of exit, and it is obvious that the loss of momentum will vary according to the velocity of the bullet at the moment when it enters the tissues, and according to the resistance with which it meets. It must also be remembered that the aperture of entry is made solely by the bullet, whilst the aperture of exit is made by it, plus the *débris* that it carries along with it; and further that the skin at the point struck is supported by the tissues beneath it, whereas at the place of exit, the skin is unsupported. This is exactly what happens if we drive a nail through a board. If supported by another piece of wood, the apertures on the two sides are even and of the same size. If unsupported, the aperture on the distant side—that of exit, in fact—will be splintered, irregular in shape, and larger than that of entry.

The sloughing which occurs around the apertures is usually more extensive around that of entry than that of exit, so that the former may, at a later stage, become larger than the latter. I saw this well exemplified in the case of a young man shot through the neck with a pistol-ball in a duel. The aperture of entry, which was at first the smaller, appeared on the second day the larger in consequence of the extrusion of a black slough; though it continued more regular in shape than that of exit.

The wounds produced by *conical bullets* may present characters resembling in general those above described, but the small size of those now used and their high rates of velocity would seem materially to modify the character of the lesions produced by them. Surg.-Capt. Perry Marsh has recorded the case of a labourer who was accidentally wounded in the thigh by the conical bullet of a Lee-Metford rifle fired at a distance of 2,560 yards. The entry wound on the front of the thigh measured $\frac{3}{8}$ in. by $\frac{3}{8}$ in.; whilst the aperture of exit behind was a "clean-cut transverse slit," $\frac{5}{16}$ in. in length. Healing took place by first intention, and on examination after the patient's death from acute bronchitis on the 54th day, the track of the bullet could not be traced. Other cases lately recorded shew that the apertures of entry and exit may be identical in character. At short ranges, however, great destruction of the bones and soft tissues appears to be produced. The experiments made in France by Delorme and Chavane with the Lebel and Gras rifles shew that under these circumstances muscles are pulped and bones extensively fissured.

Fragments of **Shell**, if of large size, inflict the most terrible wounds met with in military practice, tearing off whole limbs, or great masses of flesh, and splintering the bones in all directions. At the battle of Sedan, after the Germans had shelled a crowded mass of French troops, the ground was described as covered with "heaps of flesh and rags." A small fragment may either become lodged, or make its way out, the aperture of entry being somewhat incised, though very irregular, and the aperture of exit large and ragged.

The old round **Cannon-Ball**, in fact, solid shot of all kinds, are now quite abandoned in war, being replaced by shells fired from rifled cannon. The old cannon-balls inflicted two kinds of injury. Sometimes they contused a part deeply without destroying the integrity of the skin, the ball being "spent," and striking obliquely. In such cases the skin, owing to its elasticity, remained untorn, though all the subjacent textures—bones, muscles, and vessels—might be crushed into a pulp, if a limb were struck; or if the trunk itself were injured, the vertebral column and lumbar muscles might be disorganized, and the liver, kidneys, spleen, stomach, and intestines ruptured. These injuries, at one time erroneously attributed to the action of the current of air set in motion by the ball, were known by the name of "*wind-contusions*." In some of these contusions, gangrene of the limb set in, apparently from the rupture of the principal vessels. Cannon-shot more commonly carried away the whole thickness of a part, shattering a limb, tearing off the thick and fleshy parts of thigh, calf, or shoulder; or they inflicted the most fearful injuries by smashing the trunk and head.

SYMPTOMS.—The **Pain** in gun-shot injuries varies greatly. It is most severe when a bone is fractured, or a large cavity penetrated; when soft structures alone are injured, a dull and heavy sensation is experienced, which has often been compared to that occasioned by a blow with a stick. In many

cases, however, the sufferer is not aware that he is shot till he is told of it. I have known a person, shot in the leg by a pistol-ball, unaware that he was wounded till told that his leg was bleeding. This is especially apt to happen when the mind is actively engaged, as in the heat of battle. Hennen has known a limb carried off or smashed to pieces by a cannon-shot, without the sufferer being conscious of it. Macleod relates the case of an officer who, in the Crimea, had both legs carried away, and who was not aware of the injury till he tried to rise. Heine records a case in which a soldier ran a thorn into his foot at the same time that he received a flesh wound in the arm; he began to pull out the thorn and did not notice the arm wound until a comrade called his attention to the blood.

In gun-shot injuries, **Shock** is always very marked when parts of importance, as the head, chest and abdomen, or large joints, as the knee, are opened; and its severity is indicative of the amount of mischief inflicted. Thus, if a bullet appear to have traversed the chest, but in reality has been deflected under the skin, the comparative absence of shock will serve, to a certain extent, to prove that visceral mischief has not been inflicted. In some cases the shock alone appears sufficient to kill; thus, a man shot by a pistol-bullet, which traversed the distended stomach, died in a few seconds from shock, there being no bleeding of importance, or other discernible cause of immediate death (Taylor). In some cases, however, that are mortal, the symptoms of shock are but slight.

The **Primary Hæmorrhage** from gun-shot wounds varies according to the situation of the injury and the size of the vessels injured; *cæteris paribus*, these wounds bleed less than other injuries. When the fleshy parts of a limb are perforated by a bullet, the hæmorrhage is often very trifling, the vessels divided being small, and contused rather than cut across. But, though it may be stated as a general rule that gun-shot wounds do not bleed much, yet when a large artery, as the carotid, iliac, or femoral, is torn across, violent and rapidly fatal hæmorrhage will occur—the vessel bleeding as freely as if divided with the knife. Bullet-wounds of the large and deep arteries of the chest and abdomen are almost immediately fatal from hæmorrhage. The greater number of those who die on the field of battle perish from this cause. It has often been observed that arteries escape, though lying apparently in the direct track of a ball. In such cases, however, though primary hæmorrhage do not occur, the liability to secondary hæmorrhage is great, in consequence of the artery, which has been contused by the passage of the bullet, sloughing at a later period. The liability to primary hæmorrhage would appear to be much greater in wounds produced by bullets of very high velocity which cut through the vessels, rather than merely contuse them. This was indeed the experience of the Chilian War of 1892, in which the Mannlicher rifle was used. If the whole of a limb be torn away by a cannon-shot, the arteries of the jagged stump do not bleed, for the same reasons that those of a limb torn away by machinery do not; viz., the contraction and retraction of the ruptured internal and middle coats, and the twisting of the fibrous external coat over them.

Gun-shot wounds, under ordinary circumstances **Inflame,** with much **Swelling, Infiltration,** and **Tension.** That this should be the case is not surprising when we consider the nature of the wound and the mode of its infliction. The tissues through which the bullet passes are violently contused, the parts actually touched by the projectile are killed, and those a little more

remote are bruised and damaged to such an extent that if exposed to any further irritation, as tension or the presence of putrid matter, they readily perish. The bones, if they lie in the track of the bullet, are splintered and fissured, and the fragments are displaced and driven into the surrounding soft parts. At the same time the blood finds but an imperfect exit from the wound, and the intermuscular planes of a limb and any cavity that may be opened become distended. The exudation from the injured soft parts, that necessarily follows immediately on the injury, still further distends the part with putrescible fluid. As the nature of the external wound usually renders it almost impossible for it to heal by first intention, the whole of this decomposable matter is freely in communication with the external air, and organisms contained in the atmospheric dust find admission from without. This is often rendered even more certain by pieces of clothing and other foreign bodies being lodged deeply in the track of the bullet. By the third day, therefore, we have developed in a gun-shot wound, unless special means are taken to prevent it, one of the most dangerous conditions to which a patient can be exposed—a large accumulation of putrid matter, deeply situated, with a totally insufficient exit for the discharges. If a bone be broken, or a joint or one of the natural cavities of the body be opened, the condition is so much the worse. The bullet damages only the parts it touches ; the extension of the inflammation beyond these parts is entirely due to pent-up and putrid discharges. The extent of tissue actually killed by the contact of the ball is comparatively limited ; the wide-spread sloughing that may follow a gun-shot wound is due to the irritation of tension and of the chemical products of putrefactive and pyogenic organisms.

The ordinary course of a gun-shot wound is as follows :—As soon as the patient has rallied from the shock the temperature begins to rise. By the second day the inflammation, consequent upon the irritation of putrid matter and the tension caused by the abundant exudation from the injured tissues, begin to manifest themselves. The pain which, at the moment of infliction may have been but slight, becomes extremely acute, owing principally to the great tension. By the third day suppuration sets in, often most profuse and extensive, not only in the track of the ball, but widely diffused through the neighbouring parts. The discharges are offensive from putrefaction, and find a very imperfect exit by the comparatively narrow openings of the wound. Consequently the patient suffers severely from the absorption of septic matter, the fever being very high and the constitutional disturbance very great ; in fact, many die about this time from septic poisoning. Should a more ready exit be established for the discharges, the fever subsides by about the tenth day, as granulations spring up and limit the absorption of the products of putrefaction. A period of great danger in gun-shot wounds is that during which the sloughs separate, usually from the sixth to the twentieth day. At this period **Secondary Hæmorrhage** is very apt to come on after slight exertion. Baudens states that this occurrence is most likely to happen on the sixth day. This may be suddenly fatal, and is always more dangerous than the primary hæmorrhage, not only on account of the difficulty of arresting it, but because the patient has already been weakened by septic inflammation, suppuration, and fever. Secondary hæmorrhage may occur from causes other than the separation of the sloughs and the consequent opening up of a contused or inflamed artery. It may take place from an artery wounded by a spiculum

of fractured bone; and from the same cause it may arise at any period until all detached bone is separated and the wound firmly cicatrized. Chisholm, of the American Confederate army, mentions a case of death from secondary hæmorrhage on the 328th day after a gun-shot fracture of the upper third of the thigh, owing to a wound of the femoral artery by a detached sequestrum. Independently of this danger from secondary hæmorrhage, the patient, if his limb be saved, may have to undergo long and tedious processes of exfoliation of dead bone, and to run the risk of intercurrent attacks of erysipelas, hospital gangrene, and pyæmia.

Although a bullet wound in the vast majority of cases follows the course above described, inflammation and profuse suppuration are not inevitable results. Middleton Michel, of Charlestown, U.S.A., relates many cases of gun-shot wounds, inflicted by the Minié rifle bullet, which healed without suppuration even when the bones were injured; and union by first intention has occurred in wounds made by the Lee-Metford bullet. Such cases are sufficient evidence that the destruction of tissue caused directly by the action of the bullet is not so extensive as was at one time supposed, and that, could perfect drainage be combined with prevention of decomposition, gun-shot wounds would be robbed of half their dangers.

There is every reason to believe that warfare in modern times is fully as destructive to life as it was formerly, if not much more so; not in the proportion of the killed to the number of combatants engaged, but in relation to the recoveries among the wounded. This at first sight appears remarkable, when we consider the great advances that have been made in surgical treatment and in sanitary arrangements. But unfortunately the means by which these great advances have been brought about are seldom at the command of the military Surgeon. A very large proportion of gun-shot wounds must occur under circumstances which render antiseptic treatment uncertain or impossible; whilst the enormous number of men engaged has yielded so large a number of sick and wounded that, after the first few weeks, the sanitary arrangements have hitherto broken down under the pressure, and secondary septic diseases have made the most frightful ravages. Moreover, the advance in surgical treatment has up to the present time been more than neutralized by the more deadly nature of the injuries.

TREATMENT.—The slighter and superficial gun-shot injuries generally require merely to be treated on the ordinary principles that guide us in the management of contusions and lacerations generally. When they affect the head, chest, or abdomen, they present so many circumstances of special importance, that we must defer the consideration of them until we treat of injuries of those regions.

In all cases of gun-shot wounds, certain *immediate attentions* are necessary in order to place the sufferer in some degree of comfort and safety until more definite treatment can be adopted. It is impossible on the field to carry out antiseptic treatment with the same certainty as in a general hospital, but a great deal can be done to avoid unnecessary contamination of the wound. The fate of the soldier is truly, as Nussbaum has said, in the hands of the Surgeon who first attends him. If primary antiseptic treatment is at once used, he will have an infinitely better chance than by any other method.

It is generally believed that unless a portion of clothing or some other foreign body is carried in by the bullet, the wound may be regarded as aseptic

immediately after its infliction, infection occurring most commonly as a consequence of the introduction of an unpurified finger or probe. It is therefore now laid down as a rule that no examination of the wound should be made and no operation undertaken, except for the arrest of hæmorrhage or immediate preservation of life, until the patient has been removed to a field-hospital in the rear, where antiseptic treatment can be efficiently carried out. On the field the treatment should as far as possible be limited to the application of a pad of some absorbent antiseptic material, secured by a triangular handkerchief or a bandage. This first dressing is in most armies carried by the soldier as part of his kit.

In the British army the field dressing is sewn into a pocket on the inside of the skirt of the jacket. It consists of a compress of charpie between layers of gauze, a separate piece of gauze, and a gauze bandage. These are rendered antiseptic with 1 in 1,000 solution of corrosive sublimate. The dressing is wrapped in thin mackintosh and sewn in an outer cloth covering. A tablet of perchloride of mercury and salt (p. 208) might be added, sufficient to make a pint of 1 in 500 lotion, with which the skin might be washed before applying the pad, provided water could be obtained. Under treatment similar to this gun-shot wounds have not unfrequently healed by scabbing, even when implicating bone or joints, although so fortunate a result cannot be relied upon. Iodoform can hardly be carried in any form as a "first dressing" owing to its unpleasant smell, but enough to dust the apertures of entry and exit of many wounds could easily be carried by the Surgeon on the field, and by this means asepticity might possibly be rendered more certain. All ideas of syringing out the wound with an antiseptic and the insertion of drainage-tubes on the field are now abandoned as impracticable. If a bone or joint be injured, the limb must be placed on a splint of some kind, extemporized from such material as may be at hand. A bayonet forms a useful splint for the leg, arm, or forearm; and for the thigh a rifle may be applied to the outer side of the limb with the stock against the side of the body.

If there be abundant venous hæmorrhage, the limb should be raised; and if this do not arrest the bleeding, a compress should be used. If the hæmorrhage be arterial, a tourniquet must be applied. So, also, a tourniquet should be employed if there be rapid dripping of blood.

If a limb be smashed, or torn away, a tourniquet should be applied to the stump, which must be covered up with wet cloths. The pressure of the tourniquet will not only arrest hæmorrhage, but will stay that spasmodic quivering of the muscles which is so painful to the sufferer.

If the head or neck be wounded, the wound must be treated as above described, and hæmorrhage, whether venous or arterial, should be arrested by pressure with the fingers.

If the chest be shot through, the patient should be laid on the injured side, and cold employed. If emphysema occur, or if air pass freely through the wound, a body-bandage must be tightly applied.

If the abdomen be wounded, the patient should be laid on the injured side, if the aperture be lateral; if it be central, on his back, with the knees bent over a log or knapsack, or other support. If the intestine protrude, it must be washed and returned at once.

In addition to those immediate attentions which may be bestowed upon sufferers from gun-shot wounds before they are sent to the hospital for more

methodical treatment, the influence of the shock and pain should be counteracted by the administration of a little brandy-and-water and opium, and plenty of cold water should be given to relieve thirst.

Gun-shot Wounds in the Extremities may be divided into two great classes in reference to treatment :—I. Those that do not require amputation : II. Those in which amputation is necessary.

I. Those cases of gun-shot injury which **do not require amputation** must be treated on the principles that guide us in the management of other wounds; the Surgeon bearing in mind, however, that these injuries, unless they can be kept aseptic, are especially apt to be followed by severe diffuse inflammation, and that sloughing is very prone to occur in the track of the ball.

The first point to be attended to in these cases is the **Arrest of Hæmorrhage.** In general, this may not give much trouble; but, if a large vessel be injured, the loss of blood will rapidly prove fatal. The bleeding may in the first instance be stopped by direct pressure with the fingers on the bleeding part, followed by the application of the tourniquet, the most convenient form being the simple elastic band. If this be not at hand, some substitute must be made use of, such as a pebble, of about the size of an egg, rolled in the middle of a pocket-handkerchief and laid over the artery, the handkerchief being knotted round the limb, and then twisted up tightly with a piece of stick or the hilt of a sword passed under it (Fig. 109). The wound in the artery may render amputation of the limb necessary; if not, hæmorrhage must be arrested by making an incision down to the bleeding vessel, and applying a ligature on each side of the wounded point, for reasons that will be stated when we come to speak of Injuries of Arteries. In military practice, however, such operations for primary hæmorrhage appear to be very rare. The fact is that, if a large artery be wounded, the patient usually dies from hæmorrhage before anything can be done to arrest it. If a small vessel only be divided, the hæmorrhage will speedily cease of itself.

Fig. 109.—Gun-shot Wound of Thigh: Mode of Compressing Artery temporarily.

The second point to be attended to is the **Extraction of Foreign Bodies**, such as shot, slugs, or bullets, wadding, pieces of clothing that have been carried in with the ball, splinters of bone, and other matters of a like kind. This, for the reasons already given, should not be undertaken on the field of battle, nor is it necessary to examine the wound as soon as the patient arrives at the hospital in all cases if it is known that the bullet has not lodged. If an antiseptic first dressing has been applied and is drying on the wound, it may be left in the hope of scabbing taking place, unless a rise of temperature and increased pain show that suppuration is commencing. The modern rifle bullet, owing to its conical form and its great velocity, does not in the

majority of cases carry any portion of the clothing with it. If foreign bodies are carried into the wound they will generally be found near the aperture of exit, through which they may often be more easily extracted.

If the *bullet* lodge, it, together with any foreign bodies accompanying it, must be extracted through the wound, or cut out by a counter-opening. This second opening is often of great utility in affording a ready exit for subsequent discharges. Palpation of the limb or region struck will often lead to the discovery of the bullet, when it lies among the muscles or beneath the skin. A consideration of the direction whence the bullet came, and the position of the patient when hit, will often direct attention to the spot where the ball has lodged. If possible, the same position of body or limb should be assumed; the track of the bullet will thus be straightened, and the finger or probe can be carried down to it more readily. In searching for bullets and other foreign bodies, care should be taken not to probe the wound unnecessarily from mere curiosity, or so as to excite irritation; in many cases, the introduction of the finger is far more useful than that of the probe. The advice given by Ambroise Paré, three hundred years ago, with regard to the examination of gun-shot wounds, can scarcely be improved upon. After recommending that the examination of the wound be made as soon after the injury as possible, before swelling and inflammation set in, he says: "This is the principal thing in the performance of this work, that you place the patient in just such a posture as he was in at the receiving of the wound; for otherwise the various motions and turnings of the muscles will either hinder or straiten the passage forth of the contained bodies. You shall, if it be possible, search for these bodies with your finger, that you may the more certainly and exactly perceive them. Yet, if the bullet be entered somewhat deep in, then you shall search for it with a round and blunt probe, lest you put the patient to pain." The *extraction of the bullet* should be accomplished without delay, before inflammation has set in, and the lips and sides of the wound have become swollen. As Macleod justly observes, the extraction of the ball removes a source not only of physical irritation and suffering, but also of mental disquietude. Bullets cannot, as a rule, be allowed to remain lodged in the body with impunity. It is true that in some cases they become encysted, and so cease to irritate; but in the great majority of instances they produce suffering and constitutional disturbance, and may at last occasion fatal mischief; for, although a bullet may continue fixed for years, yet it may at last, under the influence of muscular action, gravity, or the absorption of fat, begin to move and give rise to injurious consequences. The bullet should, therefore, always be removed when possible, but if it is not readily found the attempt to discover it should not be continued too long, as more harm may result from this than from leaving it. If any foreign body be very tightly fixed, so that it cannot easily be removed, it must be left till loosened by suppuration. Sometimes a bullet is firmly fixed in the cancellous structure of the articular end of a bone, and must be removed by means of an elevator.

Various instruments are used for the detection and removal of bullets and other foreign bodies. There is usually no material difficulty in detecting the presence of a bullet, by means of an ordinary steel probe of sufficient length. When, however, the bullet is lodged deeply in the cancellous structure of a bone, or amongst swollen and infiltrated tissues, the difficulty may be great. Nélaton, in the case of Garibaldi, adopted the ingenious device of passing a

probe armed with a piece of unglazed porcelain down to the suspected site of the bullet, and noting the streak of lead left on the rough surface. Bullet-detectors have also been contrived, in which, by an arrangement of two insulated metal probes in a cannula connected with a galvanometer, the galvanic circuit is completed when the bullet is touched, and the needle of the galvanometer deflected; or, instead of the latter instrument, the ordinary telegraph alarum may be interposed, the bell of which rings when the circuit is completed by the bullet or any other metallic body being touched. These various contrivances are more ingenious than practical, and may be looked upon as surgical toys rather than as useful instruments. For the removal of bullets, long and strong forceps are required, the action of which may be aided by a screw probe.

The *splinters* produced by the passage of a ball through a bone are more numerous and larger when the injury has been inflicted by a conical rifle-ball. The impetus of this projectile is so great, and its wedge-like action so destructive, that the bone struck is shattered into a number of fragments, as well as split longitudinally, often to a great extent. These fragments are detached to a greater or less extent from their connections with the soft parts, and carried out of the axis of the limb. Dupuytren, who was fond of systematizing, classified splinters of this kind under the three heads of *primary*, *secondary*, and *tertiary*. *Primary* splinters are carried completely across the limb, detached from the soft parts, and lodged near the aperture of exit. *Secondary* splinters remain still attached by a strip of periosteum or fibrous tissue; *tertiary* are those portions of bone which, from the violence done to them, often necrose and separate at a subsequent period. The treatment of these different kinds of splinters must necessarily vary. The primary, which are already completely detached and are incapable of consolidation, must be treated as foreign bodies and extracted. The secondary, if very loose, must also be removed; but, if more firmly fixed, they may be pushed into the axis of the injured bone and left, when they may become consolidated by callus, and so serve in the reconstruction of the bone. The tertiary, which do not separate until after about six or seven weeks, must be removed as soon as possible; if they become engaged in a mass of callus, it may be a considerable time before they are loose enough to be removed; and, until then, sinuses leading down to them will remain open even for years.

The reunion of comminuted gun-shot fractures may, in appropriate cases, be assisted by resection of the fractured ends of the bones. This plan has been especially successful in the bones of the upper extremities. After resection of the ends the fragments may be kept in apposition by metallic sutures, as suggested by Howard, of the American army.

In those cases in which small shot are lodged under the skin, they may be turned out by being cut down to with a fine scalpel; when more deeply lodged, no attempt should be made to extract them.

The **Treatment of the Wound** itself must be conducted on ordinary surgical principles. As has already been stated, there will, as a rule, be violent inflammation and sloughing along the whole track of the ball, unless decomposition can be prevented; although instances have been recorded of primary union in gun-shot wounds, uncomplicated with fracture or the lodgment of foreign bodies, even without any special mode of antiseptic treatment. The principal points to be attended to are: to limit inflammation by rest, drainage,

and the use of antiseptics, to watch and facilitate the separation of sloughs should they form, and to pay scrupulous attention to cleanliness and the general hygienic surroundings of the patient.

By adopting some form of *antiseptic treatment*, inflammation may be limited, and the formation of sloughs avoided; in both civil and military practice the repair of gun-shot fractures without suppuration has been frequently obtained by this mode of dressing.

In cases occurring in civil practice the employment of antiseptics with all needful precautions is easy, and the results are correspondingly satisfactory. Kraske has published a series of twenty-three cases under the care of Volkmann in Halle, treated by strict antiseptic dressing with enlargement of the apertures, both of entry and exit, to facilitate drainage. Of these two died—one a perforating wound of the skull, and one wound of the abdomen perforating the liver, kidney, and pleura. The twenty-one cases that recovered were the following: five flesh wounds, two flesh wounds requiring primary ligature of the femoral artery for hæmorrhage, two of the arm with fracture, four wounds of the knee-joint, two perforating wounds of the skull, and six of the chest.

In military practice it is to be hoped that the simpler modes of dressing now adopted will make it possible to carry out efficient antiseptic treatment even after such battles as those of the Franco-German war. At the time of the Russo-Turkish war of 1876–77 the generally accepted antiseptic treatment was that by means of carbolic acid, including the use of the spray and the gauze dressing, and several of the Russian Surgeons attempted this. Bergmann, however, according to Surgeon-Major Melladew, found it impossible to carry it out with anything like completeness at the crossing of the Danube, where the wounded were comparatively few. The river-water was full of sand and mud, which soon choked the spray-producers, and rendered them useless; and no amount of carbolic acid was sufficient to purify it so as to take away its foul smell. Then, again, the skin of the wounded soldier, begrimed with the dust and sweat of long marches, could not be cleansed with the appliances usually at hand.

But yet, notwithstanding all these drawbacks, the antiseptic treatment did more than had ever been effected by any other; for it was by means of it that Bergmann and Reyher saved almost all their cases of gun-shot wound of the knee-joint. Reyher, who had provided himself with all the materials for Lister's carbolic gauze treatment, adopted two modes of dressing. If the apertures of the wound were very small, and no foreign bodies or splinters of bone required removal, he simply washed the skin externally with 1 in 20 solution of carbolic acid, and applied a dry gauze dressing, which was left untouched, the wound being allowed if possible to heal by scabbing beneath it. If the apertures were large, and splinters of bone had to be removed, he carried out Lister's treatment in all its details, with injection of the wound, drainage, and repeated dressings. By both these modes of treatment he obtained a large measure of success.

The best mode of carrying out the antiseptic treatment is still undetermined; but perchloride of mercury seems the most practically useful agent for cleaning the skin, disinfecting the wounds and impregnating the dressings. Carbolic acid would only be required for the instruments used during operations. The advantages of the perchloride are that it can be carried in

the solid form and occupies little space; it is one of the most powerful of all antiseptics, and the Surgeon himself or his assistants can by means of it easily convert any absorbent substance into an efficient antiseptic dressing, which, when applied, may be left undisturbed as a lasting dressing in a large proportion of cases.

The use of iodoform is strongly advocated by some Surgeons, but it is doubtful whether it would prove as efficient as the perchloride of mercury in the prevention of the effects of the unavoidable overcrowding which follows a battle.

In order to limit the inflammation, it was in former times a common practice with military Surgeons, and still is so with the French, to enlarge by incision the wound made by the ball, with the view of providing a better exit for discharges and preventing tension. John Hunter, who regarded the inflammation and sloughing that occur in gun-shot wounds as dependent solely on the contused nature of the wound, maintained that this practice only superadded another injury to the one already inflicted by the bullet; and following his precepts, British Surgeons have employed the knife in the early stages of gun-shot wounds only for the purpose of facilitating the ligature of bleeding vessels, or the extraction of foreign bodies. In the more advanced stages, however, free incisions, which should be made in the direction of the axis of the limb, are commonly required in order to lessen inflammatory tension, to prevent the extension of sloughing, and to favour the escape of discharge.

At the present time, however, when the necessity of perfect drainage is so fully understood, it becomes a question whether it would not be better practice to enlarge the wound when it is evidently too small to give a perfectly free exit to the discharges. Such a line of practice undoubtedly facilitates the antiseptic treatment, when union by scabbing is not obtained, as it renders the cleaning of the wound more easy, and for this reason it was adopted by Volkmann in the cases before alluded to.

If the Surgeon is unable to adopt any antiseptic dressing, the best mode of lessening inflammation in a gun-shot wound in the early stages, and more especially in hot climates, is cold irrigation, or if possible the application of dry cold by means of ice in india-rubber bags, conjoined with drainage and rest. As suppuration comes on, warm applications must be substituted for the cold, so as to hasten the formation of matter and the separation of the sloughs, whilst disinfectants should be freely used to the whole cavity of the wound. All bagging and burrowing of matter must be carefully guarded against by position, pressure, drainage, and counter-openings. Free incisions may also now be required. These should not be delayed too long. They may be required for three purposes: first, to relieve the tension resulting from infiltration of the limb by inflammatory effusions; secondly, to open up purulent collections and give exit to the decomposing discharges, and thus to relieve the constitutional disturbance dependent upon the absorption of the chemical productions of putrefaction; and thirdly, to extract splinters of bone, portions of clothing, and other foreign bodies that could not be removed in the first instance. When the inflammation is very acute and will not yield to the measures just enumerated, it has been recommended to compress or tie the main artery leading to the part; there can be no harm in trying the former, but the latter is not justifiable. At the period of the loosening and separation of the sloughs, there is always especial danger of the

supervention of consecutive hæmorrhage. The patient, consequently, at this time requires to be carefully watched: if the wound be in the vicinity of a large vessel, a tourniquet should be placed loosely round the limb, so as to be screwed up at a moment's notice; and, on the occurrence of bleeding, the artery must be ligatured, if possible, at the seat of the wound, or, if this be not practicable, in the most convenient situation above it. If this do not arrest the bleeding, recourse should be had to amputation.

Serious results, such as abscesses, profuse discharges, osteomyelitis, necrosis, and the separation of splinters of bone, must be subsequently looked for in many cases; and these results may be prolonged for many years, at last perhaps wearing out the patient if the cause of irritation be not removed. Thus General Bem required to have a bullet removed by Liston from the external condyle of his femur, nineteen years after it lodged there; and Marshal Moncey died from the effects of a gun-shot wound, forty years after its receipt. A soldier who was wounded at the storming of the Redan died under my care in the University College Hospital, two years and a half after that event, of exhaustion resulting from a large lumbar abscess. On examination it was found that the bullet, which had entered the left side of the chest, wounded the lung, traversed the diaphragm, notched the spleen, passed between the kidney and suprarenal body, and perforated the spine, was lying encapsuled on the right side of one of the vertebræ, pressing upon the right renal vessels. Its irritation, and that of the sequestra from the injured spine, produced the abscess, from the effect of which the patient died.

The aperture of exit usually heals sooner than the aperture of entry, probably owing to the more extensive sloughing that often takes place round the latter.

II. **Amputation** is required in gun-shot injuries in two classes of cases very dissimilar in character.

First, in cases in which the limb is wholly or in part carried away or so shattered that there could be no doubt in the mind of any Surgeon as to the necessity for immediate amputation; and secondly, in various cases in which a Surgeon, judging solely from the accidents of civil life, might not at first think the operation necessary. For example, in a bullet wound of the knee-joint, the apparent injury may be very slight, yet experience has shown that an attempt to save the limb under circumstances in which efficient antiseptic treatment cannot be adopted, rarely, if ever, succeeds.

The following is a specification of the chief conditions in which amputation is required. We have still to learn how far the use of antiseptics will enable us to modify some of these rules; but it is probable that the military Surgeon of the future will not always have the necessary materials at his command for strict antiseptic treatment, and he must then be guided in his practice by his experience of former times, and resort to amputation in cases in which, under more favourable conditions, there might be a fair prospect of saving the limb.

1. When the whole limb is carried off, a ragged stump merely being left; so, likewise, if the limb be completely crushed and disorganised though still left attached; or again, if the principal vessels be injured and the soft parts carried away, though the bone be intact, the limb cannot be preserved.

2. Amputation is especially necessary in some of the more serious injuries of the lower extremity. Thus, if a bullet divide the femoral vessels or the sciatic nerve, and splinter the thigh-bone; or if the sciatic nerve and soft parts

at the back of the thigh be carried away, although the vessels and bone be left uninjured, the case is one for amputation. It may be stated generally (though, doubtless, there are exceptions to this, as to all general rules in surgery) that in the case of a *compound fracture of the lower third of the femur* occasioned by gun-shot, amputation is the safer practice, unless the patient is likely to be placed in exceptionally favourable circumstances after the wound and the Surgeon has at his command all the means necessary for efficient antiseptic treatment.

The mortality, however, after amputation for gun-shot injury of the *upper two-thirds of the thigh*, is so great that many Surgeons have abandoned the operation in these cases, and professional opinion is unsettled as to the course that should be pursued. In the Schleswig-Holstein war of 1849, it became a question with many of the German and Danish Surgeons whether this operation should be continued, or whether the patient would not have a better chance if the injury was treated on ordinary principles as a compound fracture. At the siege of Sebastopol, the mortality after amputation in the upper third of the thigh was so great in the Russian Army that the Surgeons abandoned the operation. On the other hand, it is stated in the Report of Black Sea Fleet, that to attempt to save the limb in any case of gun-shot fracture of the thigh was to endanger the patient's life. In the Crimea, according to Macleod, a bad compound fracture of the thigh from gun-shot was synonymous with death. This was partly owing to the bad health of the troops, and partly to the terrible effects of conical balls.

Macleod states that, although he made every inquiry, he could hear of only three cases in which recovery had, in the Crimea, followed a compound fracture of the upper third of the thigh-bone without amputation. But, exceptional as were such recoveries, he states that they were not so rare as after amputation for similar injuries; as indeed was proved by the fact that not one patient recovered after amputation at the hip-joint. Hutin, the Surgeon to the Invalides in Paris, was able to discover twenty-four cases of recovery after compound fracture above the middle of the thigh, but no case of recovery after amputation for injury of the same part. In the British army in the Crimea, the amputations in the upper third of the thigh, which must have been for compound fractures low down in the bone, were fatal in the ratio of 86 per cent.; of those in the middle, probably for injuries of the lower articular end and knee, 60 per cent. died; whilst of those in the lower third, which must have been for injuries of the knee and leg, the mortality was reduced to 56 per cent. The conclusions at which Macleod arrives, after a careful inquiry into this question, are so important, that I give them in his own words. He says: "Under circumstances of war similar to those which occurred in the East, we ought to try to save compound comminuted fractures of the thigh when situated in the upper third; but immediate amputation should be had recourse to in the case of a like accident occurring in the middle and lower thirds." In the civil war in America, the opinions of Surgeons appear to have been divided; and the conclusion arrived at seems to have been that, provided the large vessels and nerves were not injured, and the circumstances in which the patient was placed as to conveyance not too unfavourable, the chance of recovery would be equal whether amputation were performed or an attempt made to save the limb. But even in these circumstances Hamilton states that, although his experience in that great war has led him to the conclusion

that in the upper third life is least hazarded by an attempt to save the limb, in the middle third conservatism and amputation afford an equal chance, whilst in the lower third of the thigh the chances are in favour of amputation. This is a conclusion very similar to that arrived at by the British Surgeons.

When an attempt is made to save the limb, the skin should be cleaned on the field of battle, if possible, with some strong antiseptic, and the limb enveloped in a large mass of some absorbent antiseptic dressing, over which a plaster-of-Paris bandage should be applied as soon as the patient reaches the field hospital. This dressing may be left untouched, unless some special circumstances require its removal, for some days until the patient reaches the hospital in which the further treatment is to be carried out. In some rare cases healing will take place under a dry scab. If at the end of four days the patient is suffering no pain and is free from fever this fortunate result may be looked for; in other cases the primary dressing should be removed about that time, and during its further progress the case must be treated by extension and counter-extension, and the free use of antiseptics, and the limb may be securely fixed in a plaster-of-Paris apparatus with a window opposite the wound.

3. In gun-shot fractures of the *bones of the leg*, amputation becomes necessary if the tibial arteries be injured, or if the knee or ankle-joint be badly wounded. If the injury be in the middle of the leg, at a distance from these joints, and provided there be not longitudinal fissuring of the bone leading into them, much may be done to save the limb, by the extraction of splinters and the removal of sharp and angular fragments of bone, the limb being put up in the plaster-of-Paris apparatus. In such cases, the patient may recover with a shortened, but otherwise useful, limb.

4. Gun-shot wounds of the *foot*, if perforating and splintering the tarsus, may commonly be saved by antiseptic treatment, but if this be not possible they require amputation, either at or above the ankle. Those of the *hand* are of special interest from their frequency, in consequence of the bursting of guns, or of powder-flask explosions. In these cases, however extensive the injury may be that is inflicted upon the hand—fingers being blown away, the thumb thrown back, and the metacarpal bones splintered—we must endeavour, if possible, to save a portion of it, if it be only one or two fingers; and, owing to the great reparative power possessed by the hand, we shall often, in the worst-looking cases, be able to accomplish this. If the thumb, with one finger as an opponent, can be preserved, it will be of more service to the patient than any artificial contrivance, however ingeniously made.

5. It may happen that amputation becomes necessary in the later stages of gun-shot injury, in consequence of mortification. In these circumstances it must be practised without delay, and without waiting for the line of separation. If, in consequence of long-continued suffering and discharge, the patient's health become greatly deteriorated, and the limb remain a useless appendage, amputation will at last be imperative.

6. Gun-shot injuries of *joints* are necessarily most serious and fatal—the danger depending on the size and complexity of the articulation, rather than on the extent of the injury. Wounds of any of the three large joints of the lower extremity are especially dangerous; those of the upper extremity are more commonly recovered from. The fact of a joint being wounded is gene-

rally obvious enough from the direction taken by the ball, the comminution of the bones, and perhaps the escape of synovia; but a joint may be fatally injured by the longitudinal splitting of the bone into it, although the bullet has not passed within some inches of it.

In bullet-wounds of joints, excision may be advantageously substituted for amputation in cases in which the soft parts are not too extensively torn, the large nerves and vessels are uninjured, and the shaft of the bone is not too widely splintered, the mischief being confined chiefly to the articular ends.

Bullet-wounds of the *head*, *neck*, or *trochanters of the femur, splintering the bone into the articulation*, are necessarily most serious. If they be left to palliative treatment, the death of the patient may be considered as almost inevitable; if amputation at the hip be performed, the prospect is better, and, though desperate, the case must not be considered hopeless. This is well illustrated by the result of amputations in the American Civil War. In *Primary* amputations at the hip-joint for gunshot injury, the mortality was, according to one estimate, 94, according to another, which I think more correct, 84 per cent. All *Intermediate* amputations were fatal; the *Secondary* ones only at the rate of 77 per cent. If the shaft be not too much implicated, it is probable that the best hope lies in excision of the splintered head of the bone, and careful removal of the loose fragments. This operation, originally proposed by Guthrie, and first successfully performed by O'Leary in the Crimean war, presents the most reasonable, though but a slender, hope of safety to the patient, and should accordingly be practised. With this view the wound must be laid freely open, loose fragments extracted, and the upper end of the bone detached, turned out, and sawn off. Of six cases in which this was done in the Crimea, one patient, O'Leary's, recovered. Gurlt, who has collected all the cases of excision of joints for gun-shot wounds which have been recorded since 1792, states that excision of the hip has been performed 139 times; 16 of the patients recovered, 122 died, and the result of the remaining case is uncertain.

Bullet-wounds of the *knee-joint* are among the most serious injuries in surgery; and this whether the bones be much comminuted or not, provided the epiphysis of the tibia or femur be perforated, or the articulation be fairly traversed or even penetrated by the ball. Prior to the American war there were seven cases in which excision of the knee had been done for gun-shot injury—five in military, two in civil practice; the two latter cases recovered, the other five died. In the American war the operation was done eleven times: in two cases, one primary, the other secondary, recovery took place; nine deaths resulted, chiefly from pyæmia. In three cases in which the patella alone was excised, death ensued. Gurlt has collected the records of 146 cases, of which 33 recovered, 111 died, and the result was uncertain in the remaining cases. These results are so bad that the operation for the future will probably be abandoned in military surgery. It is in this class of cases, however, that Bergmann and Reyher have obtained a very considerable measure of success by conservative treatment, with strict antiseptic dressing. Bergmann had 15 fresh gun-shot wounds of the knee under his care after one of the battles in the Russo-Turkish war. These were all treated by superficial cleaning of the skin with carbolic lotion and the application of a mass of salicylic wool, especially thick at the knee, secured by an elastic bandage and covered with a plaster-of-Paris apparatus. They were then immediately sent

on a four days' journey, under great difficulties from roads and weather, to the hospital at the base of operations. Of these 8 recovered without suppuration, 2 suppurated slightly, and 5 severely. Of these 5, 2 recovered without amputation, 2 after amputation, and 1 died of pyæmia. Reyher, by the employment of Lister's gauze, either as a permanent dressing to obtain healing by scabbing, or with drainage, obtained the following results: In 18 cases which came under his care before they had been probed or examined the wound united under the dry dressing, without suppuration, in 10; in 6 he treated the wound by antiseptic drainage and of these 3 died; and in 2 drainage was commenced at a later period of the case and both recovered. Thus of the 18 cases treated primarily by antiseptic dressing, 3 died, and all the survivors preserved the limb with a considerable degree of mobility in the joint. Forty cases which had been "fingered" before he saw them also came under his observation. Of these 19 were treated by drainage after occlusion had failed and 18 died; in 9 others intermediate amputation was performed, with 7 deaths; in 12 secondary amputation was performed, with 9 deaths: making a total of forty cases, with 34 deaths, and only one limb saved. Conservative treatment was attempted without antiseptic dressing in 23 cases, and of these only one finally recovered, and in that healing took place by scabbing under a dry dressing.

In all cases *in which antiseptic treatment is impossible*, conservative treatment contrasts most unfavourably with primary amputation in the lower third of the thigh. When amputation is determined on, the operation requires to be performed early, not because the apparent injury may be very severe, or the mutilation of the limb so great as obviously and imperatively to call for immediate amputation, but because experience has shown that, unless the limb be removed at an early period, after-consequences of the most serious and fatal character will to a certainty ensue. Extensive suppuration of the joint, deep and large abscesses burrowing among the muscles of the thigh, and consequent exhaustion of the patient by hectic, or his destruction by pyæmia, are the conditions that amputation alone, performed at an early stage, can avert. This necessity for early amputation in penetrating bullet-wounds of the knee-joint, when antiseptic treatment is impossible, is recognised by all modern military Surgeons. Guthrie and Larrey in the French wars, Esmarch and Stromeyer in the Schleswig-Holstein campaign, and the Surgeons in the Crimea, all found that the attempt to save a limb so injured led to the sacrifice of the patient's life.

Bullet-wounds of the *ankle-joint* do not necessarily require amputation. If the bones be not too extensively comminuted, and more particularly if the posterior tibial artery and nerve have escaped injury, an attempt may be made to save the limb, and will probably be successful; the injury being treated on the principles which will be described in the chapters on Fractures and on Dislocations. In such cases extraction of fragments, and excision of the splintered ends, are necessary; and modified operations, partial excision by means of gouge, forceps, and Hey's saw, will be found more successful than the more systematic operations. Gurlt has collected 150 cases of excision of the ankle, with 94 recoveries, 51 or 34 per cent. deaths, and 5 uncertain. If the large vessels and nerves have been cut across, and the bones very extensively shattered, amputation will be the proper course to pursue.

The *shoulder*, and more particularly the left shoulder, from its advanced

position in the act of firing, is peculiarly liable to gun-shot injury; the bullet either lodging in the head of the humerus or traversing it, and perhaps fracturing some of the bony processes of the scapula in its immediate vicinity; or, as in the case of fragments of shells, carrying away a large part of the deltoid muscle. It is especially in bullet-wounds of the shoulder and elbow-joint that conservative surgery has been most successful. In such cases, when the bones are penetrated, and even shattered by a bullet, provided the main blood-vessels and nerves of the limb be not injured, amputation will seldom be required; and indeed, it should be laid down as a rule in surgery, that excision should be preferred to amputation in all cases in which the large blood-vessels and nerves are not wounded, or the soft parts too extensively disorganised. The wound having been enlarged, loose spicula must be removed, and the splintered and jagged ends of the fractured bone sawn smoothly off. If the bullet be still lodged in the head of the humerus, as in Fig. 110, the same course should be adopted. It has been a question with Surgeons whether excision or amputation should be done when the upper end of the shaft of the humerus has been much splintered, with or without penetration of the joint. In these cases the head of the bone is often uninjured. Guthrie advised amputation; but the result of the experience of the war in America has been that five or six inches of the shaft of the humerus may be removed with perfect safety, and that no good comes of leaving the uninjured head, which should also be excised. The results of excision of the joints of the upper extremity are in the highest degree satisfactory. Thus Baudens states that he saved 13 out of 14 cases of excision of the shoulder. According to Thornton, in the British army in the Crimea, the shoulder was excised 12 times with 2 deaths; the elbow in 17 cases, of which 2 were fatal; and partially in 5 other cases, all of which were successful. These results were more successful than those that followed amputation of the corresponding parts. Of 60 disarticulations at the shoulder, 19, or 31 per cent., were fatal: and of 153 amputations of the arm, 29, or 19 per cent., died. The result of resection of these joints has not been quite so satisfactory elsewhere; thus, in the Confederate army in America, Chisholm states that up to February, 1864, of 59 cases of excision of the shoulder, 20 proved unsuccessful; and of 45 cases in which the elbow was excised, 9 were unsuccessful. In the official report of the Surgeon-General of the United States army, of 286 cases of excision of the elbow in which the results were known, it is stated that 62 died, and in 16 amputation became necessary. Of 210 primary excisions of the shoulder-joint death occurred in 50; and of 298 secondary excisions 115 were fatal, giving a mean mortality of 32·48, against 39·44 for amputation at the shoulder, and 44·4 for cases treated on the expectant plan.

Fig. 110.—Spherical Bullet in Head of Humerus.

Gurlt has collected 1,661 cases of excision of the shoulder in military surgery with 1,067 recoveries, 567, or 34·7 per cent., deaths, and 27 uncertain; and 1,438 of excision of the elbow, with 1,054 recoveries, 349, or 24·87 per cent., deaths, and 35 doubtful.

The operation of excision of large portions of the shaft of the humerus, as well as of its head, was carried much further by the American military Surgeons in the Civil War than had previously been done. Fig. 111, taken

from photographs in the possession of the Army Medical Department at Washington, represents six inches of the shaft of the humerus with its head, which had been thus excised; and Fig. 112, the arm that was left. I saw the man, who is an orderly in that unrivalled collection, the Army Medical Museum at Washington, and I can testify to the utility of his arm; the bone so skilfully taken away he himself exhibited.

Excision of the wrist, in whole or in part, for gun-shot injury has not proved very satisfactory, not so much from death as from inutility of the hand that was left. Of 27 done in the American war, only 3 died. In two instances, amputation of the forearm was practised.

Gurlt has collected 133 cases with 112 recoveries, 20, or 15·15 per cent. deaths, and 1 uncertain.

The steps of all the operations are the same, whether the excision of the

Fig. 111.

Fig. 112.—Result of Excision of Head and six inches of Shaft of Humerus shown in Fig. 111. (U. S. Army Med. Dep.)

part be required for gun-shot injury, or for disease; except that in gun-shot injury advantage may often be taken of the wound in the soft parts, by enlarging which longitudinally, the shattered bone may be readily reached.

The question as to the *period at which amputation ought to be performed* after the infliction of gun-shot wounds, is one of great importance, and has given rise to much discussion among Surgeons. The older military Surgeons, Paré, Wiseman, Ledran, Ranby, &c., taking a common-sense view of the question, advocated the removal of the hopelessly injured limb as soon as possible after the receipt of the injury. Wiseman's advice is to "cut off the limb quickly while the soldier is heated and in mettle;" and this advice has not been and cannot be improved upon. After the battle of Fontenoy, in the middle of the last century, professional opinion underwent a change upon this subject; and Faure wrote a thesis, which obtained a prize from the French Academy of Surgery, recommending delay in amputating in certain cases. Hunter, Percy

and other Surgeons of repute, expressed similar views; and Bilguer, the Surgeon-in-chief to the armies of Frederick the Great, went to the absurd length of condemning amputation entirely. These extreme opinions necessarily occasioned a reaction; and the experience gained in the wars of the French Revolution and of the Empire enabled Surgeons to settle this question definitively. It was more particularly through the observations of John Bell, Larrey, Thomson, Guthrie, S. Cooper, and Hennen, that the necessity of having recourse to immediate amputation in all cases of gun-shot injury requiring this operation became fully recognised, and the truth of Wiseman's teaching was re-established.

It is to be hoped that the advance of antiseptic surgery will enable the Surgeon to carry out conservative treatment to a much greater extent than has up to the present time been possible. When antiseptic treatment is impossible the rule of performing primary amputation in all doubtful cases must still be followed. Sir Charles Bell has thus graphically described the results of the attempts to save such cases before the days of antiseptic surgery:—"In twelve hours the inflammation, pain, and tension of the whole limb, the inflamed countenance, the brilliant eye, the sleepless and restless condition, declare the impression the injury is making on the limb and on the constitutional powers. In six days, the limb from the groin to the toe, or from the shoulder to the finger, is swollen to half the size of the body; a violent phlegmonous inflammation pervades the whole; serous effusion has taken place in the whole limb; and abscesses are forming in the great beds of cellular texture throughout the whole extent of the extremity. In three months, if the patient have laboured through the agony, the bones are carious; the abscesses are interminable sinuses; the limb is undermined and everywhere unsound; and the constitutional strength ebbs to the lowest degree."

If we appeal to statistics, we shall find that of 300 secondary amputations reported by Faure, after the battle of Fontenoy, only 30 were successful; whereas Larrey saved three-fourths of his primary amputations in the Napoleonic wars. In the Peninsular war, the loss after secondary amputations of the upper extremity was, compared to that following primary operations of the same kind, as twelve to one; and in the case of the lower extremity, the loss after secondary amputation was three times as great as after primary. During the siege of Sebastopol, among 80,000 wounded Russians there were 3,000 amputations. Of the primary amputations of the upper extremity, leg, and foot, about one-half, and of the lower and middle third of the thigh, about one-third, recovered; but of all the secondary amputations more than two-thirds died. In the American Civil War there were recorded 17,208 major amputations of limbs (excluding those at the hip and shoulder). Of these, 11,630 were primary, with a death-rate of 32·1 per cent.; 3,905 were performed between the third and thirtieth days with a death-rate of 44·5 per cent., and 1,646 were performed after the thirtieth day with a death-rate of 33·3 per cent. These figures clearly show that if the limb cannot be saved, primary amputation gives the patient the best chance.

But how soon after the infliction of the injury should it be practised? It is the opinion of some Surgeons that there is often an interval between the infliction of the injury and the supervention of the shock to the system, in which the limb may most advantageously be removed. Should the depression

of "shock" have come on, it then becomes a question whether immediate amputation should be practised, or the removal of the limb delayed until reaction sets in. On this point it is obviously difficult to lay down any very definite rule; but it may, I think, be stated generally as the result of the experience of the best Army Surgeons, that, if the shock be not very intense, the limb may, under an anæsthetic, be safely removed. Should the prostration be excessive, and there be reason to fear the possibility of internal injury, it will be wiser to delay operation. But if an unsuccessful attempt at the preservation of the limb be made, and if occasion for its subsequent removal should arise, the Surgeon must wait until suppuration has set in before he operates, the period of acute inflammation and septic fever being allowed to pass by. The most favourable time is usually about the tenth day. Among the cases that require secondary amputation, are any in which traumatic gangrene may happen to set in; here the limb must always be removed without delay. If profuse hæmorrhage from the wound occur, and do not admit of arrest by the ordinary means, secondary amputation may become necessary. So, also, when the bones do not unite, the patient being worn out by profuse discharge kept up by the presence of necrosed or carious bone, or left with a wasted, shattered, and useless limb, its removal is the only means of saving life. The high death-rate after secondary amputation in military practice is, in great measure, due to the unfavourable hygienic conditions to which the wounded soldier is usually exposed from overcrowding and want of necessary appliances. He is thus rendered peculiarly liable to be attacked by pyæmia, septicæmia, and hospital gangrene.

The nature and treatment of gun-shot injuries of special regions, as of the head, chest, and abdomen, will be considered in the Chapters devoted to the description of Injuries of those parts.

CHAPTER XI.

POISONED WOUNDS.

Two classes of poisons may gain access to a wound: first, the non-infective, which have no power of increasing in the living body, and, secondly, those which possess true infective properties and multiply in the tissues or in the blood. In the former class the effect is proportional to the dose, in the latter it is not; in the former the effect begins to manifest itself immediately, in the latter there is sometimes a period of incubation, during which no symptoms indicate the presence of the poison. Both classes may act locally or generally. When the non-infective poisons produce grave general symptoms, this is due either to the quantity introduced or to the intensity of the virus. The most important of the non-infective poisons are the venom of various insects, the poison of snakes, and the chemical products of putrefaction. Amongst the most important of the true infective poisons are the virus of rabies, of glanders, of malignant pustule, and of certain unhealthy processes in the living human body.

STINGS OF INSECTS.

Stings of Insects, as of bees, wasps, mosquitoes, gnats, &c., though painful, seldom produce any serious results; yet occasionally they prove fatal, by serving as a starting-point for erysipelas in some unhealthy constitutions, or by giving rise to intense irritation from the multiplicity of the stings, as when bees swarm upon and sting a person; or they may be dangerous in consequence of the nature of the part that is stung, as the eye, or the interior of the mouth, or the pharynx, as has happened from swallowing a bee in a piece of honeycomb. Mosquito-bites are peculiarly irritating, and when numerous poison the blood, producing nervous depression and great febrile irritation. The venom of a mosquito is very powerful, weight for weight probably more so than that of the most venomous snakes. The bites of some insects, as scorpions, or the tarantula in Italy, give rise to serious and even fatal disturbance. A peculiar train of nervous phenomena is said to follow the bite of the tarantula, hence called "tarantismus;" a condition that is generally stated to be peculiarly influenced by music, though this has been denied by Gozzo.

Treatment.—In the treatment of stings of insects the application of cooling lotions or of a cold poultice, or rubbing the part with olive oil, will be found useful. In some cases, more especially in mosquito-bites, or the stings of bees or wasps, touching the part stung with strong liquor ammoniæ or potassæ gives relief, if done at once. In the case of stings from wasps or bees, it should be ascertained that the sting has not been left in the wound. If so, it must be extracted, and the alkali applied.

SNAKE-BITES.

Snake-bites are seldom fatal in England, the viper or adder not possessing a sufficiently energetic poison to destroy a healthy adult, though it might possibly kill a child or a very weak person. Snakes are said to be most actively venomous in warm weather and during the season of procreation. Their bites are most dangerous if inflicted through a vein or near the centre of the circulation, or about the neck and face. In tropical countries the bite of the rattle-snake, the cobra di capello, the puff-adder, or the tobacco-pipe snake is often fatal. The number of persons who are annually killed by snake-bites in those parts of India alone from which returns are procurable amounts to about 12,000, or about 1 in every 5,000 of the inhabitants; and it occasionally happens even in this country that the Surgeon has an opportunity of seeing wounds inflicted by these fearful reptiles in menageries. Thus, Sir E. Home has recorded a fatal case of rattle-snake bite occurring in England. A similar instance has been seen at St. George's Hospital, and another in Paris, both in showmen. The only case of this kind which has come under my own observation occurred some years ago at the University College Hospital. The patient, a keeper at the Zoological Gardens, was bitten on the bridge of the nose by a cobra di capello, the poison-fang having apparently penetrated the angular vein. When brought to the hospital, about half an hour after the accident, he was apparently dying, being unable to speak, swallow, or support himself; the pupils were dilated, the face livid, the heart's action feeble, and he was scarcely conscious. After death, which took place in little more than an hour from the time of the infliction of the wound, the veins of the brain and the cerebral sinuses were found gorged with blood, as were also the lungs and the solid abdominal viscera. The right cavities of the heart were loaded with dark blood, the left being empty; indeed, the phenomena of asphyxia were strikingly marked. In this case, death would appear to have resulted from the poison paralysing the respiratory centre, at the same time that it exerted some direct injurious action on the blood.

Effects of Snake-poison.—The venom of the cobra has been found to consist of an albuminous fluid of neutral reaction, holding cells in suspension. The researches of Weir-Mitchell, Reichert, Wolfenden, and others have shown that the poisonous properties of the venom of the cobra and other snakes depend upon the proteid bodies which it contains, whilst bacteria and alkaloids are absent. Wolfenden finds that the chief proteids contained in cobra-poison are globulin, acid albumin, and serum albumin. The poison is secreted by a gland communicating by a duct with the hollow fang, and so situated that in the act of biting it is compressed by the muscles of the jaw and the venom is thus forcibly ejected from the fang. When given internally, or applied to the conjunctiva, it does no harm if the mucous surface is unbroken. Snake-poison, when introduced into the system through a bite or puncture, may prove injurious or may kill, either primarily by a direct depressing influence on the nervous system, like that of some narcotic poisons; or, secondarily, by exciting severe diffuse inflammation of the areolar tissue of the part. The intensity of its effects depends upon the quantity injected, and consequently upon the size and vigour of the animal inflicting the wound; one that has been compelled to bite frequently loses its destructive power.

The first mode of death occurs only when the poison is very powerful or the

animal bitten small. Thus the poison of the tobacco-pipe snake is said to be so virulent that it will kill a full-grown man in less than a quarter of an hour. The rattle-snake and the cobra will kill a small animal in a few seconds; and a man, bitten some years ago by a rattle-snake in Paris, died in nine hours; the cobra-bite above mentioned was fatal in little more than one hour; the Australian tiger-snake will kill in less than twenty-four hours.

When the snake is less venomous and death is not speedy, the poison excites diffuse inflammation and suppuration of the areolar tissue of the part. This is a very common consequence of the bite of the viper in this country. It may occur also after bites by the larger ophidia. Thus, in the case which occurred in St. George's Hospital, the patient died on the eighteenth day after the bite of the rattle-snake, with large abscesses in the arm and in the axilla, and with sloughing of the areolar tissue of the limb.

The **Symptoms** occurring after a poisonous snake-bite consist in great prostration, a feeble and intermittent pulse, dilated pupils, usually slight delirium, indistinctness or at times complete loss of speech, speedy stupor, insensibility and death. The pain is burning and lancinating, whilst the part bitten swells and becomes livid in a few hours; and if the patient survive sufficiently long, diffuse inflammation and gangrene occur in its neighbourhood; involuntary evacuations take place; the depression increases and may terminate fatally, or end after a lapse of time in the recovery of the patient, whose health may long suffer from the effects of the accident.

TREATMENT. This is local and general.

The **Local Treatment** can be carried out with success only when the patient is seen immediately after the accident, as the absorption of the poison is very rapid. It presents two great indications: 1, to prevent the absorption of the poison into the system; and 2, to treat the diffuse inflammation and sloughing that may subsequently occur. The first indication may be fulfilled by tying a ligature so tightly round the limb at a little distance above the injured part, as to arrest all circulation through it. In this way the absorption of the poison may be prevented; the wound should then be freely cauterized with a red-hot iron or cinder, or better still, excised, and a cupping-glass applied over the cut surface, so as to withdraw the blood in the neighbourhood which may have become contaminated by the poison. If a cupping-glass be not at hand, or if the part bitten be so situated as not to admit of its application, there can be no objection to the employment of suction by the mouth after free incision; the poison not being absorbed by an unbroken mucous membrane. After using suction, the mouth should be rinsed with brandy. A plan sometimes adopted when the bite is inflicted while shooting in India is to pinch the part up and cut it out at once and then to make a paste in the wound with blood and gunpowder and light it; by this means the raw surface is effectually cauterized. With the view of lessening the swelling, tension, and pain of the limb, frictions with olive oil are said to be advantageous. After diffuse inflammation has set in, this must be treated on general principles—by fomentations and free incision.

The **Constitutional Treatment** consists in the early and free administration of the most powerful *stimulants*, with the view of combating the depression that exists. For this purpose, brandy, wine, ammonia, or ether must be freely given. The *eau de luce*—which enjoys a high reputation in some tropical countries—owes its efficacy to the ammonia which it contains. Should drowsi-

...e to walk about; and *artificial respira-*
... resorted to as a last means of maintaining
Sna ... ts may overcome those of the poison.
a suf ... made to run for some distance behind a
possi ... s another means of keeping up the respira-
activ ... elimination of the poison. Large doses of
The ... as a kind of specific, and the "Tanjore pill,"
the ... its activity to this mineral; but care must
the ... ring it, lest the remedy prove as fatal as the
snal ... d. In cases of bite by the "brown snake,"
sna ... e is nearly always fatal, Halford, of Melbourne,
am ... strong solution of ammonia, diluted with twice its
occ ... al vein, such as the radial. Fifteen or thirty
of ... s is repeated according to circumstances. This is
E. ... sing the patient from his stupor. Sir Joseph
A ... his remedy has no power in cases of cobra-bite, nor
Pa ... n of Indian serpents, whatever its efficacy may be
my ... ly effects of those of the Australian species. As
H ... s the virus into a sediment and a supernatant fluid.
b ... eous, it might be supposed that it would act as a true
p ... been found to do so when injected into the blood of
h

sv ... ct to antidotes for snake-poisoning appears to exist as
a ... stion as in their discovery. The venom of a snake is at
i ... e blood of the animal bitten, is carried with the circula-
v ... entres, decomposing the fluid that conveys it, so that it
v ... antidote that can possibly be applied to prevent its direct
... e system. It is difficult to understand how an antidote
... were injected into the veins simultaneously with the intro-
... nake-poison into the blood. Unless a Surgeon be at hand
... his at the moment, as in the case of an animal bitten for
... time lost would probably render the counteraction of the
... e. It is evident that drugs or substances swallowed with the
... as antidotes could not be absorbed from the stomach in time to

... ed nothing to be done but to endeavour to keep the patient
... administration of stimulants, until the effects of the poison

BITES OF RABID ANIMALS: RABIES OR HYDROPHOBIA.

... a period of thirty-eight years, ending 1885, 938 deaths are stated to
... ed in England and Wales from bites of rabid animals.

... disease occurs in man only as the result of inoculation from one of
... animals. It is originally an affection of animals of the canine
... the dog, wolf, fox, and jackal, but it is frequently communicated by
... the cat, horse, ass, cow, pig, deer, or sheep. It is generally believed
... bies in the dog invariably arises as the result of inoculation from
... animal, and that it cannot arise *de novo*. This view is supported by
... factory results of muzzling dogs for the prevention of the disease as
... out in Berlin and elsewhere, and by the fact that rabies is unknown in

Australia in spite of the large numbers of wild dogs that infest the country, and its introduction has so far been successfully avoided by a prolonged quarantine imposed on all dogs arriving from abroad. That rabies has in rare cases followed the bite of an animal that has shown no definite signs of the disease is believed to be due to the fact that the disease is not invariably fatal in dogs, and may sometimes be so mild as to escape detection. Many circumstances have been supposed to act as predisposing causes of rabies. It undoubtedly appears in epidemics, in some years being scarcely heard of, while in others it is comparatively frequent. The season seems to have some influence on its occurrence, as Eckel found it to be most common in the early spring. Want of water, sudden changes from heat to cold, bad food, and unsatisfied sexual desire, have also been assigned as causes of its development in animals. When we inquire into the operation of these alleged causes, we fail to discover any direct and positive connection between any one of them and rabies. With regard to the influence of heat and want of water, it would appear that in those countries in which animals are most exposed to these conditions, rabies is unknown. Thus, Mr. Donovan, who has resided and travelled for many years in Central Africa, informs me that, in the deserts of that country, where water is so scarce that man and beast often die of thirst, jackals and wild dogs are most numerous, and yet the disease is unknown. The theory of rabies arising from ungratified sexual desire appears to be equally untenable. Having been told that no bitches were allowed in Sark, I wrote to Dr. Cockridge of that island to inquire if this were the fact, and if so, whether rabies were prevalent there. He informed me that there were no bitches in the island, and that the dogs were very numerous, but that no case of that disease had, to his knowledge, ever occurred there, and that the clergyman, who had had thirty years' experience of the island, had never heard of a case. Dogs become rabid more frequently than bitches; thus, of a hundred and forty-one cases collected by Eckel, only fifteen occurred in bitches.

Symptoms in the Dog.—The Surgeon is sometimes asked to give an opinion as to the condition of a dog that has bitten a person, and which is suspected of being mad. The following description of the symptoms of **Rabies in the Dog**, by Dr. Burdon Sanderson, will aid him in coming to a conclusion on these points :

"The premonitory indications of rabies in a dog are derived almost entirely from the observation of changes in its demeanour; consequently, although they may be too trifling to be noticed by a casual observer, they are fortunately sufficiently striking to arrest the attention of any one who is about a dog, and is familiar with its habits and individual peculiarities.

"A dog about to become rabid loses its natural liveliness. It mopes about as if preoccupied or apprehensive, and seeks to withdraw into dark corners. From the first there is usually a foreshadowing of that most constant symptom of the disease—depraved appetite. Mad dogs devour not only filth and rubbish of every kind with avidity, but even their own excrement—often immediately after it has been passed. Indications of this tendency appear early, and are more than suspicious.

"Along with this peculiarity of behaviour it is of equal importance to notice that an infected dog, from the first, snaps at other dogs without provocation. This snappishness in most dogs is very striking. If a dog previously known

to have no such habit, snaps indiscriminately at the first dog it meets in the yard or in the street, it is probably not safe.

"So far I have had in mind chiefly what is to be observed in dogs tied up or at home. A dog which is at large is also to be recognized as in a dangerous state by its demeanour. A healthy dog in its progress along a street or elsewhere, shows at every step that its attention is awake to the sights and sounds which it encounters. The rabid dog, on the contrary, goes sullenly and unobservantly forwards, and is not diverted by objects obviously likely to attract it. This statement, however, is subject to the important exception already referred to, that it is excited both by the sight and sound of an animal of its own species.

"Of the symptoms which accompany the final stage of the disease, the most important and characteristic are those which relate to the organs in which it localizes itself—the mouth and throat. Attention is often drawn to the condition of the mouth in an animal supposed to be healthy, by the observation that it tries to scratch the corners of its mouth, as if attempting to get rid of the ropy mucus which is seen to be discharged from it. In dogs that are tied up, it is noticeable that the bark has entirely lost its ring, and acquires a peculiar hoarseness, which can be recognized even by the most unobservant. As the disease progresses the discharge increases, the lower jaw hangs as if paralysed, and the animal has evident difficulty in swallowing. Along with this there is often loss of power in the hind limbs. If now the dog be watched, the peculiarities of behaviour which have been already noticed are seen to present themselves in a much more marked degree than before. It is observed, first, that it is subject to paroxysms of excitement, in which it makes often-repeated efforts to bite or gnaw all objects (such as woodwork, straw, &c.) within its reach, while at the same time it continues to exhibit the tendency already mentioned to devour its own excrement; and, secondly, even during the remissions, its excitement is at once renewed by the sight or sound of another dog.

"It may be well to note that the disease occurs at all seasons, that the mad dog continues to recognize its master, and to manifest pleasure when kindly spoken to, that it does not shun water, and that in many cases from first to last that wild fury which is commonly supposed to belong to the disease, is conspicuously absent."

Rabies in Man.—In man, rabies occurs either from the bite of a dog known to be rabid, or from a raw surface, as a crack in the lip, being licked by an animal affected with rabies, but in whom the characteristic symptoms have not developed themselves. The bite of a rabid animal is by no means certain to occasion rabies. The proportion of those bitten by rabid dogs that develop the disease has been variously estimated. Hunter and Vaughan (Halford) put it at only 3 to 5 per cent., while Leblanc, from statistics collected in Paris, makes it 16 per cent. Ruffer, from the consideration of a large number of statistics, assumes the proportion to be 15 per cent. The bite of a rabid wolf is far more dangerous, no fewer than 67 per cent. of those bitten dying of the disease. The bite of a cat also is more dangerous than that of a dog. The fact is that the dog usually bites at the legs, and thus when he inflicts a wound, it is through clothing, by which his teeth are wiped and the saliva arrested, and thus the wound escapes inoculation. Wolves and cats, on the other hand, always fly at naked parts of the body, as the face or

throat; hence the greater danger of their bites. There is this important difference between the poisonous inoculation of the wound by the bite of a rabid dog and of a snake. In the case of the dog the poison is only adherent to the tooth, and hence, if this be wiped in its passage through clothing, the bite is rendered innocuous. In the case of the snake, the poison is projected through the hollow fang, and hence, wherever that enters, however clean its exterior may be wiped, this drop of poison is injected into the parts at the extreme point of penetration. But making all allowance for the mechanical action of clothing in preventing inoculation of the part bitten, there is, I think, good reason to believe that there is a great difference in the susceptibility of different individuals to the poison of rabies. For it is an undoubted fact that veterinary Surgeons and others have often been bitten on an uncovered hand by rabid dogs, and yet have escaped the disease. Elliotson mentions the cases of two sisters who were both bitten on the face by the same rabid dog; the first escaped, the second died of rabies. White, of Brighton, disbelieving in the contagion of the disease, inoculated himself with the saliva of a rabid dog with impunity.

Nothing is as yet known as to the exact **nature of the virus**, and all attempts to discover a specific micro-organism in the infective secretions and tissues have so far failed. The observations of Pasteur seem to show that its activity is abolished by drying, heat, and putrefaction, but can be preserved for some time by cold and moisture. The virus exists in the saliva and salivary glands, in the central nervous system, and in the peripheral nerves, but no satisfactory proof has been given that it exists in the blood.

Period of Incubation.—Rabies differs from most other specific diseases in the length of time that the poison may lie dormant without giving rise to any symptoms. This period is very variously estimated by different writers. It is said to have been as short as three days and as long as fifteen years, but it is now generally believed rarely to extend beyond a few weeks. In only 6 per cent. of 147 authentic cases was it found to exceed six weeks. Ruffer finds that in 97 per cent. of fatal cases, death took place within four months of the bite. In the case of the Duke of Richmond, who was bitten whilst separating a tame fox and a dog that were quarrelling (it is doubtful by which animal the bite was inflicted), the disease did not develop itself for six or seven weeks. Meade has related the case of a lady who had the disease fifteen months after the bite; and Mayer, of St. Petersburg, that of a young man who died of rabies twenty-six months after being bitten; Sir Thomas Watson adduces evidence that the poison may lie dormant for years. Writers, however, who state that six, seven, twelve, and even fifteen years have intervened between the infliction of the wound and the manifestation of the symptoms, have evidently fallen into error, having probably confounded with hydrophobia other nervous affections that closely resemble it. In this long and uncertain period of incubation the disease bears some resemblance to syphilis, which may occasionally give rise to no definite symptoms, either local or general, till six weeks after inoculation.

Symptoms in Man.—The wound has generally cicatrized long before any symptoms of rabies declare themselves; and no peculiar appearance is presented by the scar. Shooting pains, twitching and itching sensations have, however, occasionally been experienced in the site of the wound before the onset of the disease.

The symptoms are usually ushered in for two or three days (according to Perry for five or six) by some antecedent phenomena, consisting of giddiness, chills and heats, and a general feeling of discomfort, whilst often the onset is marked by great depression with irritability of temper. In some cases vesicles under the tongue have been observed. The more *special* symptoms never manifest themselves until the disease is fairly established; they consist essentially in violent and repeated convulsive movements of a reflex character, induced by various external influences acting on the surface of the body or on the fauces, or by mental impressions; and they speedily end in exhaustion and death. At an early stage of the disease the knee-jerks are exaggerated.

The special symptoms are referable to an excessive irritability of the medulla and upper part of the cord, in consequence of which the slightest afferent impulse causes a wide-spreading and violent reflex spasm of the muscles of deglutition and respiration, and of those of the neck and sometimes of the jaw and tongue. At the same time there is considerable mental disturbance, chiefly assuming the form of excessive terror and agitation.

The *Excessive Irritability of the Medulla and upper part of the Spinal Cord* is shown first by the very slight nature of the afferent impulses which are sufficient to cause a reflex spasm. A blast of cold air, the rustling of the bed-clothes, the slightest touch of or movement on the skin, will bring on convulsions. As the disease advances, stimulation of the nerves of special sense produces the same effect; so that a sudden flash of light, as the reflection of the sun from a looking-glass, or a sudden noise, as the slamming of a door, will bring on a spasm. Mental impressions even may cause the same result. The noise produced by liquids being poured from one vessel to another is peculiarly distressing to the patient; and Elliotson mentions a case in which a patient with rabies was thrown into violent agitation by hearing the dresser who sat up with him void urine. The sufferings and convulsions which the patient experiences when he attempts to drink are owing to the same cause. The normal reflex contraction of the muscles of deglutition that occurs in swallowing becomes spasmodic, and spreads widely to other muscles, ending in a general convulsion, and the recollection of these sufferings makes him afraid to repeat the attempt; hence the fear of liquids, from which the name "hydrophobia" is derived.

In the earlier stages of the disease the spasm affects chiefly the muscles of deglutition and respiration; a catch in the breathing, resembling what often occurs when a person goes into a cold bath, is met with as one of the earliest symptoms, taking place in the midst of conversation, and before the patient's mind is directed to the nature of the disease. This catch is due to the spasmodic descent of the diaphragm, and gives rise to severe pain at the pit of the stomach, or to a feeling of suffocation. In consequence of this spasm of the diaphragm, the patient makes from time to time a loud hiccuping noise, which has been likened to the bark of a dog. As the disease advances the spasms extend more widely, and increase in violence. The extraordinary muscles of respiration and those of the neck and jaw are thrown into violent spasms, and the convulsions may extend even more widely. The laryngeal muscles also become affected, and spasm of the glottis is not an uncommon mode of death. Towards the end of the case the spasms may occur without any recognizable external stimulus, but just before death they may entirely cease.

From an early stage of the case there is an abundant viscid secretion from

the mouth and fauces, which the patient finds great difficulty in expectorating, often trying to pull it out with the fingers; and children may in this way scratch and tear the skin of the lips and nose.

One of the earliest symptoms, and one of the most persistent, is extreme *Mental Agitation and Terror*, a vague sense of dread and horror at the impending fate. Spectral illusions sometimes occur, the patient supposing himself to be surrounded by animals, by horrid forms, by gaping, ghastly, and grinning countenances, or by flies or wasps. The first symptom in the Duke of Richmond's case was that he fancied some poplar-trees opposite his bedroom-window to be men looking in. These delusions may alternate with fits of delirium, terror, and frenzy. In these it is said that the patient barks like a dog, and endeavours to bite; but this is a popular error—the "bark" is merely the catch in breathing, and the attempt to bite is nothing but movements of the tongue and mouth induced by the viscid saliva.

The temperature is not usually much over 100° F. Albumen and sugar have been found in the urine by F. A. Southam, the sugar doubtless depending on irritation of the medulla oblongata.

Gamaleïa, Bristowe and Horsley, and others have recorded cases of rabies in man assuming the paralytic form, which is the variety usually occurring in rabbits and occasionally in dogs—"dumb rabies." The disease then proves fatal from ascending paralysis.

Duration and Termination.—The disease may prove fatal in four-and-twenty hours, or life may be prolonged for six or seven days. Death generally takes place from the second to the fourth day, and may occur from spasm of the glottis or from exhaustion. Occasionally the symptoms subside completely before death; the increased sensibility of the surface disappearing, the mental agitation or delusion being removed, and deglutition and respiration being quietly performed. Thus, Latham relates the case of a man labouring under this disease, who sat up quietly in bed and drank a pint of porter half an hour before he died. In these cases the pulse gradually becomes slower and slower, and finally ceases. This mode of death is not exhaustion, but is due to a destructive change in the cardiac centre in the medulla.

Prognosis.—I am not acquainted with any case of recovery from rabies, and, when once the first symptoms have made their appearance the disease seems to be invariably fatal.

Pathology.—The appearances which are found after death in undoubted cases of rabies harmonize with the symptoms observed during life. The most definite and characteristic change is found in the lower part of the medulla, "most intense in the hypo-glossal, glosso-pharyngeal and vagal nuclei and their neighbourhood." Gowers found the changes identical and so clearly marked, that the nature of the affection could have been recognized from the *post-mortem* appearance alone in seven out of eight cases he examined. Nothing is visible to the naked eye, but the microscope shows *ante-mortem* clots in some of the minute vessels, and the perivascular spaces in the affected region are crowded with leucocytes. In the regions in which the disease is most advanced, the leucocytes pass beyond the lymphatic spaces and invade the tissues of the medulla, sometimes being so closely packed as to conceal the normal structures in minute spots. The only change in the nerve elements is slight granular degeneration. The appearances are, in short, those of inflammation of the affected region. These appearances were well

demonstrated by Marcus Beck in a case which occurred in University College Hospital in 1871. Benedikt and others have found identical changes in the dog. Taking the *post-mortem* appearances and the symptoms together, it appears probable that the essential feature of the disease is an infective inflammation, chiefly affecting the medulla oblongata. The first sign of damage to the nerve-elements is their loss of resistance, and the occurrence of violent and irregular action from slight causes. If the patient does not perish at an early stage from exhaustion, damage of the nervous tissue progresses till it comes to respond more feebly than natural to the different impulses it receives; this corresponds to the period of calm that so frequently occurs before death. Finally, it becomes incapable of performing its functions, and the heart ceases to beat. Coats states that he has found, in addition to the congestion of the fauces always met with, actual infiltration of the salivary glands with leucocytes. Beyond these no definite appearances are met with. Although Pasteur has not been able successfully to inoculate the blood of a rabid animal, there is no doubt that the virus can be carried to the brain and cord by the circulation. To prove this he inoculated a rabbit by injection into the auricular vein and immediately afterwards cut off the ear, but the symptoms developed as usual. The theory that the virus can reach the nervous centres by direct extension along the nerves has nothing to support it.

Rabies belongs to the class of specific infective diseases, its chief peculiarity being the unusual duration of the period of incubation. It is in no way more extraordinary than such a disease as mumps, in which a period of perfect health, lasting for three weeks, intervenes between infection and the appearance of a local acute inflammation attacking the parotid gland.

TREATMENT.—This must be principally *preventive* and *palliative*. We cannot speak of *curative* treatment of rabies; for, after the disease has once set in, the utmost that can be done is to lessen the patient's sufferings, and delay for a few hours the almost inevitably fatal termination.

Preventive Treatment.—From what is known regarding the nature and mode of spread of rabies, it appears certain that much can be done by State regulation to exterminate the disease. The most important measures are: 1. The destruction of all dogs which are rabid or suspected of being so. 2. Seizure of all ownerless and wandering dogs. According to Fleming, 249 out of 601 rabid dogs were returned as stray ones. 3. All dogs to be efficiently muzzled while rabies prevails, and for some time afterwards. The efficacy of muzzling has been amply proved; in 1885 twenty-seven deaths from rabies occurred in London, whilst in 1886, after the muzzling order was enforced, no death was recorded. 4. The registration and taxation of all dogs. Owing to the fact that but a small proportion of those bitten are attacked by the disease, innumerable popular remedies have obtained an unmerited reputation for preventing rabies.

When a person is bitten by a rabid dog, or by one that is reasonably suspected of being so, the Surgeon should always adopt energetic means to save the patient from so fatal a disease. As soon as possible after the bite has been inflicted, a string or bandage of some kind should if possible be applied on the proximal side of the wound, so as to arrest the circulation. Suction is commonly recommended, and would be almost instinctively practised; but it is not altogether devoid of danger, as there is reason to believe that inoculation may take place through the mucous membrane of the lip and mouth, and this

would certainly occur if there were any crack or abrasion. The only preventive means that can be trusted are *excision* and *caustics*.

Excision is no doubt the most effectual preventive treatment, but it is seldom practised. It should be freely performed, no half measures being had recourse to. It is better to remove too much of a comparatively unimportant tissue or part, than to allow the sufferer to run any risk of falling a victim to the fatal disease. In order to excise every part that has been touched by the tooth, the Surgeon should pass a probe to the bottom of the wound, and excise the whole by scooping out a conical piece of the tissues, taking care to go beyond the furthest limit to which the probe is passed. If there be any doubt of the removal of the whole of the injured parts, a caustic should be applied. If the lip be bitten through, a portion may be cut out, and the wound brought together, as in hare-lip operations; if a finger be injured, it may be amputated.

Caustics are much more commonly used. The introduction of a sharp-pointed stick of nitrate of silver into each tooth-mark was strongly recommended by Youatt, who had himself been bitten twenty times. Potassa fusa is also a most efficient caustic, but it is apt to extend its action farther than is intended. Liquid caustics poured into the hole left by the tooth have the advantage of penetrating very thoroughly into every part of the wound. Pure carbolic acid, or fuming nitric acid, may be used in this way. If the wound have already cicatrized, the bitten part may be excised at any time after the injury, provided the dog is known to have been mad, or to have become so afterwards: for it is not impossible that, in the cases in which the disease has occurred at a remote period, it has been dependent upon, or connected with, some peculiar action set up in the wound, which might possibly be averted by the removal of the cicatrix.

Pasteur's Preventive Treatment.—In 1880 Pasteur commenced a series of researches into the nature of rabies, as the result of which he believes that he has discovered a means of rendering an animal incapable of developing the disease if inoculated with the virus, and that within certain limits of time he can, by the same treatment, prevent the occurrence of the disease, even after inoculation of the virus on an unprotected animal. He started with the idea that it might be possible so to attenuate the virus that its inoculation might induce a modified form of the disease, free from danger to life, but protecting the animal from a subsequent attack. In this he was not successful, and his present mode of treatment, although conferring immunity, produces no appreciable disturbance of health. In this it differs entirely from vaccination. It is impossible to give here more than the briefest summary of Pasteur's work. The first definite result arrived at was the fact that the virus is constantly present in the central nervous system of rabid dogs, and can thus be obtained free from contamination by the septic organisms always present in the saliva. By crushing up portions of the cord in sterilized broth a suitable material was obtained for inoculation, and it was found that by trephining an animal and injecting the virulent fluid beneath the arachnoid, rabies can be induced with perfect certainty, and that the incubative period is reduced to from six to ten days. Pasteur next found that by inoculating a series of monkeys, using the cord of the first for the second and so on, a gradual attenuation of the virus takes place, until its virulence disappears entirely. By inoculating the attenuated virus he succeeded in producing immunity in dogs. Further observations showed that by inoculating a series

of rabbits with the attenuated virus from monkeys he could gradually restore and even increase its virulence; the chief evidence of the increased virulence being the gradual shortening of the incubative period. At last by passing the poison derived directly from a dog through a series of rabbits he obtained apparently the maximum virulence, inoculation by trephining being certainly followed by rabies on the seventh day, and at this point the intensity of the poison remained constant. The symptoms in the rabbit differ somewhat from those in the dog, the most marked feature being paralysis of the hind legs, gradually extending to the fore legs before death. After death the whole length of the cord is equally virulent. That the disease thus induced is true rabies is proved by the fact that dogs inoculated with the rabbit's cord develop the typical disease either of the dumb or the furious variety. The virus of constant strength having been thus obtained, the next point is to attenuate it so that it can be inoculated without a fatal result. The means of so doing was found in simply drying the cord. If the cord, removed with all practicable antiseptic precautions, be suspended in a glass-jar, at the bottom of which some caustic potash is placed to dry the air, its virulence gradually disappears until at the end of from 10 to 14 days it is completely lost. Pasteur inoculated dogs with this attenuated virus in the following way:—Every day a portion of cord rubbed down in sterilized broth was injected beneath the skin, commencing with some that had been dried long enough to have lost its virulence, a more virulent material being used each day till at last the fresh cord was reached. It was found that this could be done without disturbing the health of the dog, and at the end of the process the animal presented a perfect resistance to the most intense virus, nor could rabies be given to it by the bite of a rabid animal. That Pasteur and others have thus conferred upon dogs a perfect immunity to the virus of rabies cannot be doubted, but how it is done is quite uncertain. Pasteur asserts that the poison, whatever it may be, is destroyed by drying, and that it is not a true attenuation but rather a diminution in quantity that takes place as the cord dries. Although no organism has yet been found, Pasteur suggests that one may be present which produces in its growth a chemical substance hostile to its own development, a condition met with in numerous organised ferments. In the dried cord the living organism perishes gradually while the chemical antidote undergoes no change. This is, of course, merely a hypothesis.

On July 6th, 1885, Pasteur first applied his method to the human subject. The patient, Joseph Meister, aged 14, had been severely bitten in fourteen places by a mad dog. The boy suffered no evil effects from the treatment, and is still alive and well (1893). Since that time thousands have flocked to Pasteur's laboratory from all parts of Europe, and some even from America, and institutions have been founded in Budapest, Odessa, Turin, etc., where the treatment is carried out.

The treatment has been modified in some points, but the following may be taken as an example of the way in which it is carried out. The cord is pounded up with a glass rod in a quantity of sterilised veal broth equal to four times its bulk before it was dried, and of this mixture one, two, or three cubic centimetres are used in each inoculation. The injections are made under the skin of the abdomen once or twice a day. The following numbers indicate the days of drying to which the cord has been submitted at each injection:—First day, 14, 13; second day, 12, 11; third day, 10, 9; fourth day, 8, 7;

fifth day, 6, 6; sixth day, 5; seventh day, 5; eighth day, 4; ninth day, 3; tenth day, 5; eleventh day, 5; twelfth day, 4; thirteenth day, 4; fourteenth day, 3; fifteenth day, 3.

The "intensive" treatment is adopted in wolf-bites and the more severe cases of bites from undoubtedly rabid dogs. In these cases the injections are continued during twenty-one days, whilst the early injections are more numerous, so that a cord dried for six days is used on the third. No abscesses or other local troubles beyond a little tenderness and redness have in any case followed the injections.

That the treatment is not infallible Pasteur himself acknowledges; how fallible it is can scarcely yet be determined. From 1886 to 1892 inclusive, 12,744 persons underwent the antirabic treatment at the Pasteur Institute; of these 112 died, showing a mortality of 0·88 per cent. These cases are arranged in three classes: first, those bitten by animals proved by experiment to be rabid; secondly, those bitten by animals certified to be rabid by veterinary Surgeons; thirdly, those bitten by animals suspected of rabies. Of the total number treated, 10,298 had been bitten by animals proved or certified to be rabid; 95 of these died, giving a mortality of 0·92 per cent. Excluding those cases which have proved fatal from rabies during the treatment or within fifteen days of its termination, only 72 deaths have occurred in the 14,430 cases treated up to the end of 1893; this gives a mortality of only 0·50 per cent. This must be compared with the mortality of 15 per cent. which follows the bites of rabid animals treated by other methods. It can thus hardly be denied that the treatment has been productive of a great saving of life. In a considerable number of other institutions founded for the purpose of carrying out Pasteur's treatment the results have been equally satisfactory. No cases are on record proving that death has resulted from the treatment, and it is probable that those few instances in which paralysis ending fatally occurred during the "intensive" treatment were cases of "paralytic rabies."

A committee, composed of Sir H. Roscoe, Dr. Burdon-Sanderson, Sir James Paget, Sir Joseph Lister, Dr. Lauder Brunton, Dr. Quain, Dr. Fleming, and Mr. Victor Horsley, was nominated by the President of the Local Government Board in 1886 to inquire into Pasteur's treatment, and after a most exhaustive investigation, as a part of which Horsley repeated the experiments on animals, the committee reported in 1887, fully confirming Pasteur's conclusions on every important point.

The treatment can of course be carried out only in institutions established for the purpose, as it is necessary to keep a large number of rabid rabbits constantly in stock, for if from any cause the intensified virus as developed in the rabbits died out it would take some months to develop it again by a fresh series of inoculations starting from a rabid dog.

The treatment may be commenced at any time before the invasion of the disease, but the chances are of necessity very seriously diminished after a fortnight from the date of the bite.

Palliative Treatment.—After the disease has once set in, nothing can be done but to *palliate symptoms* and prolong life. Every possible remedy that the ingenuity of man could devise, from warm water to viper- and ticuna-poison, has been tried and found utterly useless.

But, although no treatment hitherto tried has been successful in curing this horrible disease, much may be done to mitigate the sufferings caused by

it. All sources of external irritation, whether physical or mental, should be removed. The patient should be placed in a darkened and quiet room, and not subjected to the intrusive curiosity of strangers; and the bed should be surrounded by curtains or screens, so as to prevent the disturbing influence even of a draught of cold air blowing on the surface. Chloroform may be administered by inhalation, or chloral may be injected subcutaneously in 10 to 15 grain doses every second or third hour, in order to calm the violence of the spasms and to procure sleep, but care must be taken not to push it too far lest coma result.

In a case lately in University College Hospital the patient experienced great relief from having the fauces occasionally brushed with a solution of cocaine.

The hot air or vapour bath often affords great temporary relief, and diminishes in a marked manner the violence of the spasms.

The subcutaneous injection of curare has been strongly recommended, and doubtful cases of cure by its means have been reported. The dose is from $\frac{1}{8}$th to $\frac{1}{4}$th of a grain every third hour. Mercury pushed to salivation was formerly recommended both as a preventive and a curative treatment. Andry (1779) relates numerous cases, apparently authentic, in which it seems to have been of use. Tracheotomy has been recommended in order to avert death by spasm of the glottis. But what possible good can result from preventing death by this cause when it is impending from another? Lastly, the Surgeon must bear in mind that he has to treat an exhausting disease, and that he must consequently support the patient by wine, beef-tea, and such nourishment as can be taken.

MALIGNANT PUSTULE.

Malignant pustule or charbon is the name commonly given to the affection produced by the inoculation, on the cutaneous surface in man, of the virus of the disease of cattle known as splenic fever or anthrax. Splenic fever is fortunately rare amongst animals in this country, while in France and some parts of Germany it occurs with considerable frequency amongst horned cattle, horses, and sheep. Malignant pustule is consequently also rare here, being met with chiefly amongst workers in foreign hides or wools; on the Continent it is common also amongst butchers. The virus has now been clearly proved to be a large, easily recognisable microscopic organism, the bacillus anthracis. It may find entrance into the body by the lungs or intestines in the form of dust, and then it gives rise to a general disease running a rapid and fatal course without the formation of an external centre of inflammation. This affection, which is known as "woolsorters' disease," was brought prominently into notice by the occurrence of several fatal cases at Bradford amongst workmen engaged in sorting Persian and Bokharan wools. Malignant pustule assumes an importance quite out of proportion to the frequency of its occurrence: first, because of the necessity of recognising it early for its successful treatment; and secondly, because it forms a type of a true infective process, both local and general, and its exact pathology is better understood than that of most other diseases of the same kind.

Symptoms.—The first symptom of malignant pustule is the formation of a small angry red pimple on some exposed part of the body—either the face, hands, or arms. The patient may be conscious of having scratched or pricked

himself at the point at which the pimple appears, or he may rightly or wrongly attribute it to the bite or sting of an insect. The pimple is accompanied by intense itching, and after some hours a vesicle forms on its summit, which is burst by the patient's scratching it. There now forms a distinct indurated patch, which rapidly extends; at first it is grey in colour, but by the end of the second day the central part is black. The skin in the neighbourhood becomes red and swollen, and round the edge of the black patch a ring of vesicles is formed. The individual vesicles are about the size of mustard-seeds. There now follows considerable swelling of the surrounding parts with enlargement of the neighbouring lymphatic glands, and if the pustule is seated on the arm, red lines may run up towards the axilla. The rate of progress varies considerably, but by the fifth or sixth day the black eschar may attain the size of a florin, and the surrounding swelling may affect the whole side of the face or the greater part of the arm. Beyond the itching there is but little pain. The constitutional symptoms are not severe at first, but by the fourth or fifth day the temperature rises to 101° or 102°, the pulse becomes quick and irregular, the tongue dry, and the patient suffers from headache and a feeling of general severe illness. There may be dyspnœa or fainting, diarrhœa, and occasionally delirium. If no treatment be adopted, the case most frequently terminates fatally in less than a week from its commencement. The whole process may, however, remain local and cease of itself, the redness subsiding, the slough separating, and the resulting granulating sore healing with considerable disfigurement. This favourable termination is, however, very rare.

In some exceptional cases, the result of the inoculation may be a widely diffused œdema without the formation of a distinct localized inflammation. This form is rapidly fatal. If the patient survive beyond three or four days, eschars and pustules may form in the swollen part. This form has been described by the French writers under the name of "*malignant œdema*."

The internal form—"*woolsorters' disease*," or, as it has been called, *anthracæmia*—belongs rather to the Physician than to the Surgeon. The disease begins with a great sense of illness—sometimes with a rigor—vomiting, and headache, followed by high fever, marked dyspnœa, and coldness of the extremities; usually fatal collapse rapidly ensues. It may assume a pulmonary form, in which the symptoms resemble acute pneumonia or bronchitis; or an intestinal form, in which vomiting and purging are marked features. The whole illness may last less than two days, or may be prolonged to four or five. Woolsorters' disease is extremely fatal.

The **diagnosis** of malignant pustule is not difficult when the characteristic features are well developed. The black eschar, surrounded by vesicles, around which again is a bright red zone, and the wide-spreading œdema are characteristic. If there is any uncertainty, microscopic examination of the blood or inflammatory exudation will clear up the doubt.

Pathology.—After death from malignant pustule, the body presents the appearances usually met with in cases of malignant blood-poisoning. Rigor mortis is of short duration and feebly marked, there being frequently early decomposition and marked *post-mortem* staining of the tissues. The blood is dark in colour, and imperfectly coagulated, and minute extravasations of blood are found beneath the serous and mucous membranes throughout the body. There is swelling of most of the abdominal viscera, but the spleen,

especially in the lower animals, shows the greatest change; it is swollen, black in colour, soft, sometimes almost diffluent; the mucous membrane of the stomach and intestines is frequently redder than natural, and may be marked by patches of hæmorrhage. The lungs are usually gorged with blood, especially at their bases.

Locally it is found that the eschar is hard and dry, and penetrates deeply into the subcutaneous tissue, but not beyond. The neighbouring lymphatic glands are enlarged and redder than natural.

Microscopic examination of the local lesion, of the blood and of the viscera shows everywhere the presence of a microscopic organism of considerable size—bacillus anthracis (Fig. 113). This organism was discovered by Pollender as long ago as 1849, but its complete life-history and its definite relation to splenic fever have been more recently worked out by Davaine, Chauveau, and Pasteur in France, Koch in Germany, Klein, Ewart and Greenfield in this country, and a multitude of other observers. The bacillus anthracis is a rod-shaped organism, varying in length from $\frac{1}{2500}$ to $\frac{1}{1250}$ of an inch, and of an average breadth of about $\frac{1}{18000}$. Thus in human blood the length of the bacilli may reach between two and three times the diameter of a red corpuscle, and their width to about one-quarter of its thickness. The organism is abundantly present in the diseased skin and in the blood in "malignant pustule" in man. In the affected skin it shows a marked predilection for the most superficial parts of the papillary layer of the cutis immediately beneath the rete Malpighii, as shown by Barker in a case which occurred in University College Hospital. By cultivating it in suitable fluids out of the body its mode of growth can be observed. It multiplies when growing actively by increasing in length till it reaches a certain size, and then dividing by fission at or near its middle. When growing in this way the filament remains homogeneous in structure throughout; it is easily destroyed by exposure to a moderate degree of heat, and by carbolic acid and all other chemical antiseptics. The length of the filament as compared to its breadth varies considerably according to the medium in which it is cultivated. When grown on solid media (nutrient gelatine, agar-agar, or potato), with free access of air, spore-formation takes place, and the same will happen in fluid media if the organism for any reason floats on the surface. The spores appear as minute highly refracting dots, in the protoplasm of the bacillus. After they have formed the organism may break up, leaving only the spores, surrounded by a little jelly-like material; or the spores may be quite free, or still situated in very short segments of the original rods. It has been proved by experiment that under

Fig. 113.—Bacillus Anthracis in Lung.

proper conditions these spores grow into the fully-developed bacilli—that they are really genuine germs of the fungus. From their extremely small size it is evident that if dried they could without difficulty be transported from one place to another as dust in the air, and it is, in fact, these dried spores that serve as the poison both in malignant pustule and woolsorters' disease as seen in this country. Wurtz and Lodge have cultivated the bacillus from the dust of a rag-warehouse in Bradford, in which a worker had contracted pulmonary anthrax. The power of resistance of the spores to injurious influences is so great as to render the task of disinfection after splenic fever undoubtedly difficult. The experiments of Robert Koch have shown that blood containing spores of the bacillus may be dried, and even allowed to putrefy in drying, and kept afterwards for years without losing its virulence. The spores may be exposed to a moist heat of 212° F. for a very short time, or to a dry heat for a longer period, without injury. Alcohol, glycerine, watery solutions of carbolic acid (1 to 20), salicylic acid, thymol, and weak solutions of permanganate of potash are equally powerless to destroy their vitality. On the other hand, freshly prepared chlorine-water, bromine (2 per cent. solution), iodine, perchloride of mercury (1 in 5000 in water), or permanganate of potash (5 per cent. in water), destroy their vitality. This extraordinary resisting power is fortunately shown only by spores, and as far as we know the ordinary bacteria of putrefaction and all micrococci, whether septic or pathogenic, multiply only by fission, and are, like the bacillus when not in the spore-bearing stage, readily destroyed by heat and chemical antiseptics.

That the organism is the actual cause of the disease is proved by the fact that when the bacillus is in the spore-bearing stage it may be washed with distilled water, alcohol, and ether, and then dried, and after all this, if inoculated, it is capable of producing splenic fever in the animal experimented on. After inoculation it produces its local effects probably by setting up chemical changes of a fermentative character in the fluids of the part, giving rise to intensely irritating products, which, by a process analogous to cauterisation, cause inflammation, and, soaking into the surrounding lymph-spaces, give rise to the spreading œdema and inflammation beyond the area in which the organisms are actually growing. When the bacilli get into the blood and grow widely throughout the body, they are supposed to act partly by causing mechanical obstruction of the capillaries, and partly by robbing the blood of its oxygen; for, like all fungi, they absorb oxygen during their growth. This would account for the dyspnœa and cyanosis usually met with before death from malignant pustule.

Pasteur, from numerous experiments, came to the conclusion that if the bacilli are cultivated in a fluid medium at a temperature of from 107·6° F. to 109·4° F., they do not form spores, and if grown in this way for about twenty days they become less virulent, or, as it is termed, the virus is attenuated. In this state if inoculated on a sheep they give rise to a modified form of splenic fever which is not fatal, and Pasteur affirms that after recovery from this the animal may be inoculated with the most intense virus with impunity. The analogy between this process and vaccination gave a peculiar interest to Pasteur's observations, and numerous observers have repeated his experiments with the result of generally confirming his statements that the virus may be attenuated by various means, and that if inoculated in this form it produces a power of resisting the infection of splenic fever, lasting from nine

months to a year. The attenuation of the virus may be brought about in various ways. Thus Klein states that the blood of a sheep dead of anthrax will invariably cause death if inoculated on a sheep, but if the disease be communicated to a white mouse the blood of that animal, although teeming with bacilli, only causes a transitory illness in a sheep, and leaves it, for a time, protected against the virulent form of the disease. Klein has also shown that the virus may be attenuated by being acted on by very dilute solutions of perchloride of mercury, and that if inoculated in this form on sheep it will produce a modified form of the disease which will protect them from virulent anthrax. It has also been shown by J. T. Cash that the rabbit, which is an animal very easily infected with anthrax, may be protected from the action of the most intense virus by preparing it for some days before by the hypodermic administration of perchloride of mercury in as large doses as it can bear.

One other point may be briefly noticed. Sidney Martin has shown that the bacillus anthracis produces by its growth in artificial culture media, and in the living body certain definite chemical products. These are albumoses—anthrax proto- and deutero-albumose—and a basic body, provisionally called an alkaloid. In small doses the albumoses produce fever, and in large doses local œdema and coma. The basic body on the other hand, produces, even in small doses, coma ending in death, and often enlargement of the spleen. These observations are obviously of the greatest importance; but the exact relation of the chemical products to the production of immunity is still uncertain. Martin has, however, shown that Pasteur's vaccine contains both the albumoses and the basic body, whilst Hankin believes that immunity can be produced by the albumoses alone.

It is needless to point out the important bearing of these observations upon numerous questions of pathology and therapeutics, such as infection in general, vaccination, modification of diseases by passing through different animals, changes in form of micro-organisms according to the medium in which they are grown, disinfection, antiseptics, and the influence of mercury on infective processes, &c. The whole subject of anthrax and the bacillus anthracis is one that will well repay the time spent in a thorough study of it. It is impossible to make here more than a passing allusion to the work that has been done.

The *Treatment* of malignant pustule must be energetic and active; no half measures are likely to be successful. The whole indurated area of the skin should be removed with the knife, and to the raw surface thus left some powerful antiseptic should be applied; perhaps the best would be a strong solution of iodine, which has been shown by Koch to be capable of destroying even the spores of the bacillus.

In London, malignant pustule has been most frequently seen at Guy's Hospital, as the chief part of the hide trade is carried on in the neighbourhood of that institution; during a period of ten years seventeen cases came under the care of the Surgeons. The treatment by excision was employed in fifteen cases, and of these all but two recovered. The favourite application after excision was chloride of zinc, either in a strong solution or as a paste. Davies-Colley, who reported these cases in the Transactions of the Medical and Chirurgical Society for 1882, states that "it is very important to remember that, even after the swelling has extended to a considerable distance, and the adjacent glands have been affected, and after well-marked symptoms of blood-poisoning

have developed themselves, the patient may be restored to health by the removal of the indurated area of skin which was primarily attacked."

GLANDERS.

Glanders is a virulent disease, communicable by contagion to man from the horse, ass, or mule. In spite of the intense contagiousness of the disease and the frequency with which it occurs among animals of the equine species, it is rarely met with in man.

The poison of glanders gives rise to two forms of disease in the horse, one known as *glanders* proper and the other as *farcy*.

Glanders in the Horse almost invariably runs a chronic course. The first symptom is a thin watery discharge from the nose, which, as the disease progresses, becomes viscid and tenacious; lastly, it becomes purulent, offensive, and mixed with blood. The inflammation extends through the whole nasal cavity and frontal sinuses, and is accompanied by ulceration. There is also marked swelling of the lymphatic glands under the jaw. The disease may exist for some time without seriously impairing the health of the animal, but gradually loss of appetite and strength, emaciation, and cough set in, and death takes place from exhaustion. Before death the disease always becomes complicated by the second form or farcy.

Farcy is characterised by swelling of the lymphatic glands in various parts of the body, especially on the inside of the thighs, and under the fore leg. The lymphatic vessels leading to and from the glands become inflamed, forming hard, tender cords with swellings opposite the valves. These form the "corded veins" and "farcy-buds" of the farriers. The swellings opposite the valves enlarge and become adherent to the skin, and finally ulcerate, forming foul sores. The disease may at any time become complicated with acute glanders. Acute glanders is merely a great exaggeration of all the symptoms with high fever, hurried respiration, and cough.

The *post-mortem* appearances of glanders in the horse are a dark redness and swelling of the pituitary membrane, with numerous small white elevations and patches, softening in the centre so as to form ulcers. A similar condition extends to the mucous membrane of the bronchi. In the lungs are numerous consolidated patches, varying in size from a millet-seed upwards, opaque yellow in colour, and softening in the centre, sometimes having the appearance of minute abscesses. With these may be patches of pneumonia. Gamgee describes as occasionally present in the lungs large masses of a bluish-white colour and lardaceous appearance, sometimes as big as a hen's egg. Subserous petechiæ are common.

Glanders and Farcy in Man usually occur together and run an acute course, although occasionally they may become chronic. The disease is always communicated by inoculation, usually into a scratch or other wound; but cases have been recorded in which it seemed to have been communicated through unbroken mucous membrane. The inoculation is followed by a period of incubation, which is said to vary from two days to two weeks. The invasion is marked by fever and a great sense of illness. There may be rigors, vomiting, and diarrhœa. In some cases there have been such severe pains in the limbs that the disease has been mistaken for rheumatism. The seat of inoculation becomes inflamed, and the nearest lymphatic glands

become enlarged and tender. Inflamed lymphatic vessels, with hard knots opposite the valves, may also be present. At a period after invasion varying from two days to a week or more, a characteristic *eruption* makes its appearance. This consists at first of red spots like flea-bites, which soon assume the form of elevated yellowish tubercles situated in the structure of the true skin or immediately beneath it. From their shot-like feel they may at first resemble the early stage of small-pox pustules, but they are not umbilicated and are more deeply situated, as shown by Boyd. They soon soften, forming minute abscesses in the cutis vera, the contents of which are at first hæmorrhagic. They then burst, leaving small yellowish ulcers discharging a thin purulent fluid. Together with these there may also be a vesicular eruption. There soon sets in an offensive discharge from the nose, at first watery, but afterwards puriform, and the lymphatic glands under the jaw enlarge. Finally, subcutaneous abscesses form in various parts, which may be accompanied by hæmorrhages into the muscles and intermuscular tissue; pneumonia or pleurisy may occur before death. Abscesses may be found in internal organs, as the liver or lungs. The final stages resemble pyæmia in many respects. Throughout the case the constitutional symptoms are of the gravest kind. There are great depression, high fever, delirium, and rapid emaciation. In some exceptional cases the disease may run a very chronic course.

Diagnosis.—The disease may resemble rheumatism before the eruption appears, but the appearance of the latter soon clears up the case. The eruption, as before stated, somewhat resembles that of small-pox, but the general symptoms of this disease are wanting. The history of the association of the patient with glandered horses is an important element in the diagnosis. As a means of diagnosis in doubtful cases occurring among horses the subcutaneous injection of an extract prepared from pure cultures of the bacillus of glanders has been employed. This so-called "mallein" causes a rapid rise of temperature to the extent of two or three degrees in glandered horses, whilst the effect upon the temperature of a healthy animal is insignificant.

Pathology.—The *post-mortem* appearances are much the same as those observed in the horse. There are the usual signs of grave blood-poisoning—early decomposition, excessive blood-staining of the vessels and tissues, and subserous petechiæ. Scattered points of suppuration are found throughout the body, and sometimes extensive hæmorrhage into the muscles. The lungs are usually more or less consolidated from pneumonia, and contain yellow nodules, softening in the centre, like the so-called pyæmic abscesses.

The microscopic characters of the lesions are the same, whether they occur in the skin or the respiratory tract. A small nodule of granulation-tissue forms and increases in size. The central part soon undergoes fatty degeneration and softening, and an ulcer is formed by the giving way of the skin or mucous membrane over it.

In 1882 Schütz and Löffler, two of the assistants in Koch's laboratory in Berlin, discovered the presence of a bacillus of a definite form in all the parts affected with the specific processes of glanders. This bacillus was cultivated for four generations out of the body in the serum of horse's blood, and finally inoculated on two healthy horses. Both animals speedily died with all the symptoms of glanders. The bacillus is very small, about the size of that of tubercle. Further observations have conclusively proved that the bacillus mallei is the actual virus of the disease, as the bacillus anthracis is of anthrax.

Duration.—The disease proves fatal usually in a week or fortnight, but may extend to a month. It occasionally assumes a chronic form in the human subject and lasts for several months.

Prognosis.—If the disease assumes the acute form, death is almost certain to follow. When it becomes more chronic, according to Durham, about one half of the cases recover.

Treatment.—Beyond the general treatment of supporting the patient, opening the abscesses, and freely using antiseptics both for the nose and the local sores elsewhere little can be done. Those who have care of the case must protect their hands by india-rubber gloves, if possible, while dressing the sores; and all dressings or rags which have become soiled with the discharges must be immediately burned.

WOUNDS WITH INOCULATION OF DECOMPOSING ANIMAL MATTER,* AND THE PRODUCTS OF UNHEALTHY INFLAMMATIONS.

Although every student of anatomy frequently cuts himself in dissecting, we rarely see any ill effects from these injuries. In some cases, however, the most serious results, terminating in permanently impaired health, or even in death, ensue. The result depends quite as much on the state of health of the person injured, as on the condition of the body from which the poison is received. If the health be broken by any cause, whether dissipation or overwork, very serious effects may follow, which would not occur if the patient had the resisting power of a sound constitution. Many persons are peculiarly liable to be affected by exposure to septic influences. They suffer in various ways,—such as nervous depression, sore throat, or diarrhœa—from working in dissecting or *post-mortem* rooms. The same thing happens from exposure to the contaminated atmosphere of a crowded hospital ward, and more especially to the exhalations arising from patients affected with phlegmonous erysipelas, pyæmia, gangrene, or other septic diseases. The susceptibility is greatest in those least frequently exposed to such infections. Those who habitually work in such an atmosphere seem to become acclimatised to it after a time. If for a time the habit is broken, they suffer on resuming their work as much as those exposed for the first time. A person so suffering in health is peculiarly liable to local or general infection on the receipt of a dissection-wound.

Causes.—The deleterious influence exercised by the dead body may be attributed to three different causes: 1, the ordinary Irritation of the Wound; 2, Inoculation of Putrid Matter; or, 3, Introduction of a Specific Septic Virus into the system. I think it probable that each of these causes may exercise a distinct influence; but the worst effects of dissection-wounds are dependent on the inoculation of a specific virus.

1. That ill effects sometimes result from the simple **Irritation of the Puncture,** is evident from the fact that mere scratches or punctures with splinters of wood, or other substances free from an actual poison, give rise to considerable local disturbance in certain states of the constitution; so, also, those operation- and dissection-wounds which are ragged and torn, such as are made by spicula of bone or the teeth of a saw, are peculiarly troublesome.

* See also Chapter XXXI.—Septicæmia.

2. **Putrid Animal Matter** is always irritating, but, as has before been pointed out, putrefaction cannot attack living tissues, and the effect produced is consequently limited to the local irritation caused by the chemical products of the process. A small puncture, which, if made with a clean knife, would heal by the first intention, may, if exposed to the irritation of putrid animal matter, inflame and suppurate, forming a small ulcer; but, unless the general health be seriously impaired, no further trouble is likely to occur.

3. The worst forms of *post-mortem* wounds arise from the inoculation of the **Specific Virus** of some infective inflammation, such as erysipelas, pyæmia, and septicæmia. The virus is contained in the exudation fluids from the unhealthy inflammation, and its nature has already been alluded to when discussing the causes of inflammation. In cases attended with the milder forms of localised suppuration, the virus is most commonly one of the varieties of the staphylococcus pyogenes. In the more severe spreading forms the streptococcus pyogenes is almost invariably found. The diminution of the intensity of the poison when putrefaction sets in is supposed to be due to altered conditions after death, which are more favourable to the development of the ordinary bacteria of putrefaction and less favourable to the growth of the specific organisms which consequently perish. However it is to be explained, the fact is undoubted that a few hours after death, whilst apparently quite fresh, the body is in the highest degree infective and dangerous; advanced putrefaction lessens the danger. Of all *post-mortem* poisons, that which is present in the fluid filling the cavity of the abdomen in septic peritonitis, whether following parturition or operations, is by far the most noxious. I believe it to be impossible to immerse the hand in it with impunity if there should happen to be a scratch, puncture, or abraded surface of any kind on it. Inoculation most commonly occurs through an accidental wound or scratch during the *post-mortem* examination; but a raw surface partly healed, or the fissures in chapped hands, or the small cracks so common at the margin of the nail, may equally serve as points of inoculation. In rare cases, infection takes place through the unbroken skin, the hair follicles seeming to serve as points of entrance. In the graphic account given by Sir James Paget of his own case, the poison is stated to have been absorbed through the unbroken cuticle of the hand immersed in pyæmic effusion into the pleura.

That the poisonous influence from the bodies of persons who have died of septic diseases is transmissible to others by contact or infection, cannot be denied; and accoucheurs and operating Surgeons should abstain as carefully as possible from performing *post-mortem* examinations on patients dying of such diseases, lest the poison be carried to and excite similar morbid processes in their patients. Much of the septic disease that used formerly to prevail in hospitals was engendered in this way, and infective disease has often thus been carried out of hospitals and communicated to private patients by Surgeons neglecting hygienic precautions.

Symptoms.—From what has been stated above, it would appear that there are two distinct kinds of mischief resulting from dissection wounds. First, the purely local form, proceeding from the irritation of putrid matter acting on the unbroken skin, or on a scratch or wound; and, secondly, the true infective form, spreading widely from the point of inoculation.

Of the purely local affections, the most common is the small *pustule* so often met with in the dissecting-room. About twelve to twenty-four hours after

inoculation the punctured part becomes painful, hot, and throbbing; at the end of about forty-eight hours a small drop of pus is seen raising the cuticle. If this be punctured, a small superficial sore is seen beneath, and the pain is at once relieved. If the sore be now properly dressed it heals without trouble, but if not, a small scab forms, the pus accumulates beneath it, the pain and throbbing return, and are again relieved by removing the scab. This may be repeated several times. There is neither glandular swelling nor constitutional disturbance.

Suppuration in the hair-follicles and the formation of boils is an occasional result of the action of putrid fluids on the unbroken skin of the hands.

Suppuration of the matrix of the nail arises from inoculation of a fissure at the side of the nail. The root of the nail is softened and loosened by the suppuration beneath it. The condition is often very chronic, and the nail usually separates when recovery takes place.

A somewhat rare affection resulting from the frequent and prolonged contact with putrid matter is the so-called *dissecting-porter's wart* or *anatomical tubercle*. It is always seated on the knuckles or back of the hand. It consists of a warty thickening of the skin without ulceration. The surface may be moist, and the discharge if allowed to dry may form crusts; in other cases it may be scaly on the surface. The enlarged papillæ are closely set, and the diseased condition tends slowly to spread. In the case of one of the dissecting-porters at University College who suffered from this affection, the patch measured about one inch and a half in diameter. It was cauterised without much effect, and was finally cured after many months' treatment by keeping it constantly moist, so as to prevent the formation of crusts on the surface, and by the prolonged application of equal parts of extract of belladonna and glycerine. The investigations of Riehl and Paltauf and others tend to show that, in some cases at least, this affection is tuberculous in nature.

The infective processes that arise from dissection-wounds assume two forms. In the *milder form* the punctured part becomes painful, hot, and throbbing, in from twelve to twenty-four hours after the injury; the finger becomes red and swollen, the lymphatics of the arm are perhaps affected, and the glands in the axilla become enlarged. There is general febrile disturbance, ushered in by rigors, a feeling of depression, and often intense headache; suppuration takes place about the puncture, and also, perhaps, in the inflamed glands, the case presenting the ordinary characters of whitlow with inflammation of the lymphatic vessels and glands.

In the *more severe form* of dissection-wound, the patient is seized, about twelve or eighteen hours after the puncture, with rigors and depression of the nervous system; the countenance becomes anxious, the pulse quick, and there is high fever. On examining the finger, a pustule, or vesicle, with an inflamed areola, may be observed in the situation of the puncture; from this a few red lines may be seen extending up towards the arm-pit, where there may be swelling and tension. In the worst cases, however, the signs at the seat of inoculation may be either wanting or scarcely recognizable. Suppuration, accompanied by much pain, takes place in the pectoral and axillary regions; it is usually diffuse, the pus being mixed with shreds and sloughs. The general symptoms gradually assume an asthenic type; the tongue becomes brown, sordes accumulate about the lips and gums, low delirium sets in with a rapid feeble pulse, and death

occurs in from ten days to three weeks. When incisions are made into the brawny tissue, it is found to be infiltrated with thin pus, and in a sloughy state. If the patient live, large circumscribed abscesses form under the pectoral muscles, in the axilla, and above the clavicle, accompanied by much exhaustion and depression of the system. The convalescence is tedious and prolonged, and the constitution is often shattered for life.

In other cases a diffuse inflammation, identical in all its characters with the so-called phlegmonous or cellular erysipelas, spreads directly from the seat of inoculation. That this form of dissection-wound is of a truly specific character, is evident from the fact that patients labouring under it may communicate fatal erysipelas to their nurses and attendants; as happened in the case of the late J. P. Potter, of University College Hospital, whose early death was much to be lamented. It is this kind of dissection-wound that is especially apt to occur after infection from patients who have died of diffuse inflammation of the serous membranes.

Sometimes the intensity of the spreading inflammation is such that it terminates rapidly in gangrene of the affected part, and the disease then resembles in most of its features genuine spreading or traumatic gangrene. A case of this kind occurred in a nurse under the care of Christopher Heath in University College Hospital in 1880. It resulted from the prick of a pin received in laying out the body of a lady who had died of puerperal fever. The patient's life was saved only by amputation at the shoulder-joint on the sixth day after the accident. In this case, as is usual in this form of disease, there was no enlargement of the lymphatic glands in the axilla.

The symptoms produced by contact, independently of any wound, with the bodies of persons who have died of erysipelatous diseases or pyæmia, sometimes vary, though still referable to the introduction of a poison. Thus I have known a body to infect seriously in different ways six students who were working at it. Two had suppuration of the areolar tissue under the pectorals and in the axilla; one was seized with a kind of maniacal delirium; a fourth had typhoid fever; and the remaining two were seriously, though not dangerously, indisposed.

Treatment.—On the receipt of a puncture in dissection or in making a *post-mortem* examination, the best way to prevent injurious consequences is to tie a string tightly round the finger above the injury, thus causing the blood to flow, and perhaps to carry the virus out with it. The part should then be well washed in a stream of cold water at a tap, or better still in a solution of carbolic acid (1 to 20 of water), or of perchloride of mercury (1 in 500), and sucked for some minutes; in this way any poisonous matter that has been introduced may usually be got rid of. It is better not to apply nitrate of silver; it irritates the finger, and fails to penetrate to the deep parts of the puncture. Dissectors should bear in mind that the state of the constitution exercises great influence upon the effects of the puncture; and that, in proportion as the health is sound and the body not exhausted by overwork, there is less likelihood of any injurious consequences ensuing.

In the slighter forms of dissection-wound, attended by a moderate amount of inflammation, the whole finger should be thickly painted with extract of belladonna diluted with an equal quantity of glycerine; this should be covered with cotton-wool, or with warm fomentations of boric acid lint, while the hand should be elevated and kept at absolute rest in a sling or in a splint. If

the lymphatics become inflamed, the belladonna and glycerine should be thickly painted along their course, and the arm enveloped in cotton-wool.

The general treatment of clearing out the bowels with a free purge, followed by moderate stimulation, must be adopted in the early stage; but tonics and strong support will soon be required, and if there be much constitutional irritation, opiates may advantageously be administered.

The treatment of the more severe forms of dissection-injury consists principally in the application of glycerine and belladonna with hot fomentations in the early stages, followed by early and very free incisions into the finger, axilla or pectoral region, or wherever else the part may become tense and brawny. These should be made, if there is much tension, even though matter have not already formed, with a view of preventing suppuration. Should abscesses form, they must be opened early. All incisions should be made with antiseptic precautions, and treated afterwards by some of the modes of antiseptic dressing already described. Even when sloughs have formed, they are not putrid, and the patient's danger will be greatly increased should they be allowed to become so. In the constitutional treatment, our great reliance, after administering a free purge, is on the administration of bark, ammonia, wine, and brandy, with such fluid nourishment as the patient can take; the case being treated as one of the worst forms of asthenic inflammation. If the patient survive, he must be sent as soon as possible into the country, and must devote some months, perhaps, to the re-establishment of his health. The punctured part often continues irritable for a great length of time, even for many years, remaining red, inflamed, and desquamating, pustules sometimes appearing on it. This condition is best remedied by the occasional application of nitrate of silver.

In conclusion, I cannot too strongly urge upon the dissecting student that, unless he take scrupulous precautions as to cleanliness and disinfection, he may readily contaminate with septic poison any patient whose wound he dresses. No dissecting student or operating Surgeon who has examined a dead body ought to approach a patient who has an open wound without changing his coat and thoroughly disinfecting his hands, by washing them for at least five minutes in hot water and soap, and afterwards soaking them in some strong antiseptic solution, such as carbolic lotion (1 in 20), solution of perchloride of mercury (1 in 1000), or tincture of iodine and water (ʒij to Oj).

CHAPTER XII.

EFFECTS OF HEAT AND COLD.

BURNS AND SCALDS.

A **Burn** is the result of the application of a degree of heat sufficient to produce inflammation of the part upon which it acts, or even charring and complete disorganization of its tissues. A **Scald** is occasioned by the action of some hot fluid, giving rise to the same destructive effects, although the appearances produced are different.

LOCAL EFFECTS.—Burns and scalds vary greatly in the degree of destruction of tissue to which they give rise: this variation depending partly upon the intensity of the heat, and partly upon the duration of its application. The sudden and brief application of flame to the surface causes but very slight damage to the cuticle, with some hyperæmia of the skin. If the part be exposed for a longer time to the action of the flame, as when a woman's clothes take fire, the cutis itself may be destroyed; and if the heat be still more intense, as when molten metal falls upon the body, the soft parts may be deeply charred, or the whole thickness of a limb destroyed. So, also, the effects of scalds vary greatly, not only according to the temperature of the liquid, but according to its character; the more oleaginous and thick the fluid, the more severe, usually, will the scald be.

These various effects of heat have been arranged by Dupuytren into six degrees. This is a classification of great practical importance, as the degree and character of the resulting cicatrix are dependent on the depth to which the burn penetrates.

In the *first degree*, the application of heat has been momentary. It is followed by redness and pain. There is dilatation of the vessels, simple hyperæmia, but no destruction of tissue; and consequently there is no resulting cicatrix. The constant repetition of a burn of this degree may, however, cause a disturbance of healthy nutrition. Thus in old people who sit constantly before the fire or over charcoal foot-warmers, the skin of the legs, especially in front, becomes pigmented and indurated, as a consequence of the frequently recurring hyperæmia induced by the heat. Ulceration readily occurs from slight causes in the damaged integument.

In the *second degree* the injury done by the heat is sufficient to cause dilatation of the vessels, retarded blood-flow, and exudation. The corneous layer of the cuticle is loosened and raised from the Malpighian layer by the exudation from the vessels of the inflamed cutis, and thus vesicles or blisters are formed. When these burst, the surface left beneath is still completely covered with epithelium. There is no loss of substance beyond that of the corneous layer of the cuticle. The raw surface left may discharge a little puriform fluid, the cells which it contains being partly young epithelium from the Malpighian layer and partly leucocytes which have wandered to the surface. Although

no cicatrix results in these cases, yet discoloration of the integument is often left. If the cuticle be not removed, the inflammation speedily subsides and is followed by desquamation.

In the *third degree* the whole of the cuticle is destroyed, with a portion of the true skin, but the *cutis vera* is not entirely destroyed. This is a most important point, as it materially influences the character of the resulting cicatrix. The thin layer of the true skin remaining contains sweat-glands, hair-follicles and elastic tissue—structures which are not reproduced if once destroyed. Moreover, round each hair, in the ducts of the sweat-glands and in the hollows between the papillæ, epithelium is left uninjured, from which new cells can start growing. The tips of the papillæ have their epithelium completely destroyed, and consequently become covered with granulation-tissue, so that the whole surface assumes a vivid red tint and suppurates freely. It is, however, covered with epithelium with marvellous rapidity, owing to the innumerable points from which the new cells start growing. It scarcely contracts in healing, and the scar that results is elastic and contains all the elements of normal skin. Owing to the exposure of the nerve-endings in the papillæ this form of burn is intensely painful.

In the *fourth degree* there is destruction of the skin through its whole thickness, so that the subcutaneous tissue is reached. The eschar separates by ulceration from the surrounding parts, and a large granulating sore is left which can become covered by epithelium only from its edges. Consequently the healing is slow and attended with long-continued suppuration and great contraction. The resulting cicatrix is, therefore, much smaller than the original raw surface, and is devoid of glands, hair, and elastic tissue; at first it is thin, red, or purplish, glazed, often in the form of bands or bridles, and is apt to occasion great deformity by the cohesion of parts, as of the fingers or by contraction, as at the elbow, and the side of the neck and face, or by the closure of apertures, as of the nostrils.

Most severe burns reach the fourth degree in some part at least of their extent. In practice it is not easy to distinguish between the third and fourth degrees until the sloughs begin to separate, but when the skin is hard and parchment-like and brownish-yellow in colour, the burn has probably reached the higher degree.

In the *fifth and sixth degrees* the destructive influence of the burn penetrates to a greater or less depth into the muscles, bones, or joints. In the fifth degree, the more superficial muscular structures are implicated; in the sixth degree the whole thickness of the limb is destroyed and charred.

These various degrees are usually found associated to a greater or less extent; indeed, in the more severe cases, the first three or four degrees are almost invariably met with together.

The scars of burns have been credited with some peculiar power of contraction, but there is no reason to believe that the granulation-tissue formed to repair a loss of tissue presents any differences corresponding to the particular injury which caused the mischief. Burns are the injuries in which the largest granulating sores are met with; and, as we have before seen, contraction is an essential part of healing, and the amount is directly proportional to the size of the sore and the looseness of the parts. This process of contraction continues for many months after the sore has become covered with epithelium, giving rise frequently to the most distressing deformities, sometimes rendering a limb

completely useless. These cicatrices are composed of dense fibrous tissue, and often extend deeply between and bind together the muscles, vessels, and soft structures of a limb, of the face, or of the neck.

CONSTITUTIONAL EFFECTS.—When in an ordinary conflagration a person is "burnt to death," the fatal event is occasioned not by the charring of the body, but by asphyxia. Life is mercifully extinguished by suffocation in the smoke before the body itself is consumed. To what particular product of combustion the asphyxia is due, is somewhat uncertain. There is reason to believe that in most cases carbon monoxide rather than carbon dioxide is the cause of suffocation. If the patient is not killed outright, the constitutional effects resulting from burns are most serious and important; they depend not so much upon the depth of the injury as upon its situation, the extent of surface implicated, and the age of the patient. Thus a person may have his foot completely charred by molten iron, with far less constitutional disturbance and danger than if a larger surface of the body be scorched to the first and second degrees. Burns about the chest, the head, and the face, are thought to be more likely to be attended by serious constitutional mischief than similar injuries of the extremities. Children generally suffer more severely from burns than adults. The fever that follows a bad burn is partly due to the reaction after extreme depression, but the two chief causes are undoubtedly the inflammation produced by the burn and the absorption of the products of putrefaction from the raw surface. Experiment has shown that the charred surface resulting from a burn, so far from presenting a barrier to the entrance of septic matter into the system, as is sometimes supposed, is in reality equal in its power of absorption to a raw surface made with a knife. Unless special precautions are taken, therefore, to prevent decomposition in the sloughs, the amount of septic products absorbed is very large, and the resulting fever proportionally severe.

After a severe burn the constitutional disturbance may often be divided into three stages: 1, Depression and Congestion; 2, Reaction and Inflammation; 3, Suppuration and Exhaustion.

1. The stage of **Depression of the Nervous System and Congestion of Internal Organs**, occupies the first forty-eight hours; during which death may occur. Immediately on the receipt of a severe burn the patient becomes cold and collapsed, and is seized with fits of shivering, which continue for some time. He is suffering evidently from *shock*, and the severity of the shivering is usually indicative of the extent of the constitutional disturbance. It is more prolonged in those injuries that occupy a great extent of surface, even though the burn be only of the first or second degree, than in those which, being of more limited superficial extent, affect the tissues deeply. In many cases of extensive burn the patient suffers no pain although perfectly conscious. This is a very grave sign, indicating the severest shock. On the subsidence of the symptoms of depression, there is usually a period of quiescence before reaction comes on. At this time *vomiting* is a common and troublesome symptom, and the patient, especially if a child, not unfrequently dies comatose; death resulting from congestion of the brain and its membranes, with, perhaps, serous effusion into the ventricles or in the subarachnoid space. Besides these lesions, the mucous membrane of the stomach and intestines, as well as the substance of the lungs, may be found congested.

In 40 *post-mortem* examinations made at University College Hospital in

cases of burn proving fatal within forty-eight hours, the contents of the cranium are stated to have been congested in 15, several of which showed excess of fluid in the subarachnoid space and in the ventricles; in 18 there was congestion of the lungs; and in 17 the abdominal viscera were more or less markedly congested, the kidneys alone being affected in 2, and the duodenum in 2; in one case there were "two or three small ulcers" in the third part of the duodenum.

2. The next stage, that of **Reaction and Inflammation**, extends from the second day to the second week. The action of the heat which causes the burn is momentary, and produces its full effect instantaneously. The inflammation which is the direct result of the heat sets in therefore at once, and if no other cause came into play it would be accurately limited to the part acted on, and begin to subside after the first few hours. This is, however, not the case in the majority of burns. By the end of the second day the inflammation is still increasing in intensity and extent. The burnt area is surrounded by a wide-spreading blush of redness; swelling, heat, and pain become prominent symptoms. With these there is fever proportional to the extent of the burn. It is important to consider, therefore, what is the cause that not only maintains but extends the inflammatory process long after the original cause has ceased to exert any influence. In burns accompanied by death of considerable portions of tissue, the presence of the dead matter no doubt gives rise to some irritation in its immediate neighbourhood, but the great cause of the inflammation that occurs during the first week of a bad burn is the decomposition of the adherent sloughs, and the fever that accompanies the process is in great part due to the absorption of the chemical products of putrefaction. It is during this period that a large burn becomes so horribly offensive unless special means are adopted to prevent it. Death during this stage may be connected with some inflammatory condition of the gastro-intestinal mucous membrane or of the peritoneum. The lungs are also frequently affected, showing marked evidence of pneumonia or congestion; cerebral affections are less common than in the first stage, though they may present more unequivocal evidence of inflammation.

In 38 cases examined *post-mortem* during this stage, the brain and its membranes were congested in 7; the lungs were congested in 15; there was pneumonia in 2, bronchitis in 4, and petechiæ in 3; the abdominal viscera showed a generally congested state in 5, whilst in 5 the stomach and duodenum only were affected, the duodenum alone in 4, and the kidneys alone in 1. In one case there were two ulcers in the first part of the duodenum. The *post-mortem* appearances are, in fact, those of acute septic poisoning, possibly complicated in some cases by a true infective process.

It is in this stage of burn that the very serious and rare sequela, **Perforating Ulcer of the Duodenum**, may occur. Attention was first directed to it by Curling, who suggested that the ulceration commenced in Brunner's glands. It is far more probable that it is due to the acid contents of the intestine acting on a point in the mucous membrane in which a capillary embolism has lodged. In favour of this view are the following facts: first, the ulcer occurs most frequently at that period of the case in which the patient is suffering from the absorption of septic matter from the sloughs in the skin, a condition in which capillary embolism is of common occurrence; secondly, it is usually met with in the first part of the duodenum near the pylorus before

the contents of the bowel have been neutralised by the bile; thirdly, signs of active inflammation are usually wanting in the mucous membrane surrounding the ulcer; and lastly, a similar ulceration has been recorded as occurring in a case of septicæmia not due to burn. The ulcer may rapidly proceed to perforation, exposing the pancreas and possibly eroding the superior pancreatico-duodenal artery and causing fatal hæmorrhage. In other cases it may open into the serous cavity of the abdomen and cause death from peritonitis. Ulceration of the duodenum is met with most frequently in patients under ten years of age, but as extensive burns are most common in children, it may not be proportionally more frequent in them than in adults. It is said rarely to occur before the tenth day, but Cæsar Hawkins met with it once in a child six years old, who died four and a half days after the burn; and in a child nine years of age, who died on the fourth day, in University College Hospital, I found an ulcer in the duodenum about the size of a shilling, with sharp-cut margins. In this case the mucous membrane generally was inflamed. That these ulcers are not invariably fatal is evident from a case mentioned by Curling, in which, on death occurring from other causes, eight weeks after the injury, a recent cicatrix was found in the duodenum. Ulcer of the duodenum seldom occasions any very marked symptoms to indicate the nature of the mischief; the patient generally sinks suddenly. In some instances there is hæmorrhage; though this is not an unequivocal sign, as I have several times seen bleeding from simple inflammatory congestion of the intestinal mucous membrane. Pain in the right hypochondriac region, and perhaps vomiting, may also occur.

In 94 consecutive examinations after death from burns, ulceration of the duodenum was found in only two cases.

3. The stage of **Suppuration and Exhaustion** continues from the second week to the close of the case. In it we frequently have symptoms of hectic, with much constitutional disturbance from the long continuance of exhausting discharges. If death occur, it is most frequently induced by inflammation of the lungs or pleura; affections of the abdominal organs and brain being less frequent during this stage of the injury. Pyæmia is not uncommon.

In 16 cases ending fatally after the second week, congestion of the brain was found in 2; in 6 cases there was pneumonia, and in 3 bronchitis; the abdominal viscera were free from congestion in 13, whilst in 2 there was congestion of the stomach and intestines, and in 1 of the duodenum only. In no case was the duodenum ulcerated.

Prognosis.—The influence of extent, degree, and situation on the prognosis of burns, has already been stated. The most fatal element in these injuries is *superficial extent.* It is generally believed that recovery cannot take place if one-third of the surface of the body be affected. Not only are the cutaneous nerves greatly irritated, and the nervous system generally severely affected from the shock of an extensive burn; but, owing to the arrest of the cutaneous secretion over a large surface of the skin, congestion of the internal organs and of the mucous membranes ensues: hence death may happen directly from this cause, or from the supervention of inflammation in the already congested parts, more particularly in the early periods of life. The *degree* of burn influences the prognosis unfavourably rather as far as the part itself is concerned, than as the general system is affected. The most fatal *period* in cases of burn is the first week after the accident. In 100 cases of death from

these accidents, 73 proved fatal before the eighth day; 42 of these dying on the first day. Of the remaining 27 cases, 12 died in the second week, 9 in the third, 3 in the fourth, 2 in the sixth, and 1 in the ninth.

TREATMENT.—The treatment of burns must have reference to the constitutional condition, as well as to the local injury. A vast variety of local applications have been recommended by different Surgeons, such as flour, starch, cotton-wadding, treacle, white paint, gum, solution of india-rubber, &c.; the principle of all these applications is, however, the same, viz., the protection of the burnt surface from the air. I shall here content myself with describing the methods that are usually followed with much success at the University College Hospital.

The **Constitutional Treatment** is of the utmost consequence. We have seen how death occurs at various periods after these accidents from different causes, and we must modify our treatment accordingly. The first thing to be done after the infliction of a severe burn is to bring about reaction; the patient is trembling, in a state of extreme depression, suffering great pain, and cold and shivering, and he may sink from the shock unless properly supported. Under such circumstances the local treatment of the burn must be postponed until the shock has been relieved. A full dose of liquor opii, varied according to the age, should be given at once in some warm brandy-and-water, and repeated, if necessary, in the course of an hour or two; and the patient should be wrapped in hot blankets.

When the body is extensively but superficially burnt, the immersion of the patient in a warm bath gives instantaneous relief, soothing the pain and removing the depression.

When reaction has fairly set in, the patient's secretions should be kept free by the administration of an occasional mild purgative. Should any inflammatory symptoms about the head, chest, or abdomen manifest themselves, appropriate treatment is required. I have certainly seen patients saved in these circumstances by blood-letting and the application of leeches. But, in the vast majority of instances, the visceral complications are of a congestive type. In such cases our great reliance must be on stimulants. Ammonia and bark, brandy and wine, require to be given freely, with a sufficiency of nourishment; and the irritability of the nervous system must be soothed by frequent and full doses of opium. At a later period, when the strength has become impaired by the profuse discharges, this tonic and stimulating plan must be actively continued.

Local Treatment.—In all cases of extensive burn the charred clothes must be removed, and the patient laid upon a blanket and protected as far as possible from exposure to cold. The objects aimed at in the further treatment are the protection of the raw surface, which in all degrees of burn below the fourth is acutely sensitive, the prevention of decomposition, and the exclusion of cold. In burns of the first degree no treatment is necessary beyond protecting the surface from the air. In cases where scorching of the face results from a gas explosion, Heath recommends that the skin be painted with a mixture of one part of collodion and two of castor-oil. In burns of the second degree the blisters may be punctured and the fluid allowed to drain away, but the cuticle should not be removed. The whole part may then be wrapped in cotton-wool and left untouched for a few days, by which time it will have quite recovered. In the third and succeeding degrees of burn, sloughs

have to separate and suppuration will take place, and prevention of decomposition consequently becomes of the first importance. The extent of the raw surface, however, and the readiness with which absorption takes place from it, render it unsafe to apply any antiseptic possessing powerful toxic properties, and for this reason it is better not to use carbolic acid or perchloride of mercury. Boric acid, salicylic acid, eucalyptus oil, and creolin, are the most powerful of the non-toxic antiseptics. Boric acid may be applied either by means of boric lint soaked in a concentrated solution of the acid and covered with oiled silk, or as ointment (p. 212) spread on strips of linen. If much sloughing is expected, the former is the better plan; if little, the latter. The dressing must be changed every day after suppuration has commenced. This is usually a very painful process, as even the ointment adheres more or less to the raw surface. To overcome this difficulty and at the same time to cleanse the parts thoroughly, warm boric acid baths are of the greatest service. The patient should be immersed in the bath with the dressing on, and the latter should be carefully removed when it is thoroughly soaked. The bath should be as warm as the patient can comfortably bear, and he should remain in it for about half an hour. About ten drachms of boric acid to every gallon of water makes an efficient antiseptic bath. If there is much discharge it should be absorbed by a layer of salicylic wool over the boric dressing in order to prevent putrefaction as far as possible. Creolin has been used with the best results; it may be employed as a lotion or ointment, in the strength of ½ to 2 per cent. Iodoform may be sprinkled on the surface if the discharge becomes foul, but caution must be used in its application, especially in children, as symptoms of poisoning (p. 212) may arise. In the absence of the necessary materials for these modes of treatment the following plan will be found comfortable to the patient, and satisfactory in its results. The whole burnt surface, whatever may be the degree of burn, should be well covered with the finest wheaten flour by means of an ordinary dredger. The flour should be laid on thickly, but uniformly and gradually; it forms a soft and soothing application to the surface. If the cuticle have been abraded, the flour will form a thick crust, by admixture with the serum discharged from the broken surface. If the skin be charred, the discharge which will speedily set up around the eschar will make the flour adhere to the part, forming, as it were, a coating impervious to the air. The crusts thus formed should not be disturbed until they become loosened by the discharges, when they should be removed. In this mode of treatment the decomposition of the discharges is retarded and limited by the dryness of the dressing.

A common remedy in iron-works and other places where burns are common is the so-called *Carron-oil*, composed of equal parts of linseed-oil and lime-water, to which a small quantity of spirits of turpentine is sometimes added. It is applied on lint. Whatever local application be adopted, I hold it to be of the utmost importance in the early stages of the burn to change the dressings as seldom as possible; if dry dressings are used, they should not be changed until they have been loosened by the discharges. Every fresh dressing causes the patient very severe pain, produces depression, and materially retards the progress of the case.

When the sloughs have separated, the granulating surface must be managed on ordinary principles. It is important, however, to select some form of

dressing that will not stick to the sore, otherwise the granulations may bleed every time it is changed to such an extent as seriously to weaken the patient. To prevent this, the green "protective" oiled silk may be applied directly to the sore and covered with dry boric lint or salicylic wool: under this plan of treatment the dressing is perfectly painless. If the granulations become prominent they must be touched with nitrate of silver. Epithelium-grafting is often very useful in hastening the healing.

Prevention and Removal of Contraction.—The most serious deformity may result from the contraction which necessarily occurs during the cicatrisa-

Fig. 114.—Cicatrix of Lip and Neck.

Fig. 115.—Contraction of Elbow from Cicatrix of Burn of Fourth Degree.

tion of a large granulating surface. After burns about the chin and front of the neck the lower lip becomes everted, and the chin drawn down towards the sternum (Fig. 114); and in burns on the inside of limbs or at the flexures

Fig. 116.—Dislocation backwards of Little Finger from Contraction of the Cicatrix of a Burn of the Fourth Degree.

Fig. 117.—Deformity of Left Hand from Burn of the Fifth Degree.

of joints, more especially the elbow, the contraction may greatly impair the utility of the part (Fig. 115). In bad burns of the hands the fingers may be drawn into the palm, may become webbed together, or may be dislocated and fixed immovably against the dorsum (Figs. 116 and 117).

Similar contractions may occur in the foot, leaving great deformity, as in Fig. 118, where the heel is shown to be retracted, and the whole of the toes spread out in a fan-shape. In this case Pirogoff's amputation was the only means left of securing an useful limb.

Corrosive fluids, such as strong sulphuric acid, produce effects very similar to those that result from the more severe degrees of burn; the cicatrices are irregular and contracted, and often rugged and warty.

In the treatment of the granulating surface left by a burn, much may be done to limit the amount of contraction by employing the method of skin-grafting recommended by Thiersch. This has already been described on page 278; it is a most valuable method of treatment, and is especially applicable to burns about the face in which deformity of the lips or eye-lids is likely to follow. During the healing process the part must always be fixed in a proper position by means of bandages, splints, and mechanical contrivances adapted to counteract the tendency to contraction of the cicatrix, and the consequent deformity.

Fig. 118.—Deformed Foot from Burn of the Fourth and Fifth Degrees.

The contracted cicatrices resulting from burns may, if of recent date, be stretched out by the pressure of strips of plaster or elastic bandages, the traction of india-rubber bands, or the action of rack-and-pinion apparatus. The good effect of this plan of treatment is especially marked in contractions at the elbow, or in those that fix the arm to the side. These means are particularly useful in children, and indeed are so in all cases, provided the cicatrix be not too old—not more than a year; after that time, it will seldom yield without division.

Operations for the Removal of the Effects of Contraction consequent upon burns are occasionally required, and may do much to improve the patient's condition. The operations are of two kinds: 1. Simple division of the Faulty and Contracted Cicatrix; 2. The Transplantation of a flap of adjacent healthy Skin into the gap left after the division of the cicatrix.

1. In the first operation, that of simply **Dividing the Cicatrix,** three points require special attention: 1st, that the division extend completely through the cicatrix from side to side into the adjacent healthy skin; 2ndly, that the incision be carried through the whole depth and thickness of the cicatrix into the healthy adipose tissue beneath it, which may always be recognised by its yellow colour; 3rdly, that all contracted bands lying in this layer be fairly divided. The great obstacle to the success of this operation, however, consists in the fact that the new granulations, which spring up after the division of the contracted cicatrix, in their turn contract whilst healing. After the division of the cicatrix, also, it may be found that the subjacent structures have been so rigidly fixed in their abnormal position as not to admit of extension. It may then be necessary to employ screw-apparatus, or even to divide fasciæ and tendons, before the part can be restored to its normal shape. Care must, however, be taken in doing this, that subjacent structures of importance, such as large blood-vessels, or nerves, be not so closely connected with the cicatrix as to render wound or division of them unavoidable. In the neck, cicatricial bands will often come into very dangerous proximity

to the external jugular vein, which becomes greatly distended by the pressure thus exercised upon it. And at the elbow, which is a common seat of contraction from burns, the brachial artery may become involved in the cicatrix to a dangerous extent. I have heard of one case in which this vessel was divided in cutting through the cicatrix, when amputation of the arm was immediately resorted to.

These operations are most successful in cases of contraction at the flexures of the joints. If the contraction be of very long standing, the arteries and nerves will have become shortened, and incapable of stretching under any force that may safely be employed; hence they may easily be torn.

2. Operations undertaken for the removal of the disfigurements that occur about the face and neck as the result of burns, require much management. In these cases, simple division of the cicatrix is insufficient; and **Transplantation of a Flap of Skin** is required in addition. After the cicatrix and all cicatricial bands have been freely divided in accordance with the rules just given, a flap of integument, of sufficient size to fill the greater part of the gap, must be dissected up from the neighbouring parts of the neck, chest, or shoulder, and laid into the cicatrix. There it should be fixed by sutures; but extreme care must be taken that no traction be put upon it, lest

Fig. 119.—Incisions in Teale's Operation for Cicatricial Deformity of the Lower Lip.

Fig. 120.—Teale's Operation: the Flaps in place.

it slough. Even if union takes place by the second intention a very satisfactory result may often be obtained.

The flaps must be cut much larger than the raw surface which they are intended to fill, in order to allow for the shrinkage due to the elasticity of the skin. Croft has obtained excellent results by operating in two stages. First, a strap of skin is raised from the healthy surface near the cicatrix, but is left attached at its two ends until the under surface has granulated. During this time the skin is prevented from re-uniting by a strip of protective oiled silk slipped beneath it. Secondly, the cicatricial bands are freely divided, and after cutting through one end of the bridge of skin, the latter is drawn across the raw surface and adjusted with sutures. In one case treated by Croft in this way, the strip of skin measured nine inches in length and two and a half inches in breadth. The directions given by Teale for the restoration of the lower lip when dragged down, everted, and partially destroyed by cicatrisation following a burn, are so simple and lead to such excellent results, that I give them nearly in his own words. The everted lip is divided into three parts, by two vertical incisions three-quarters of an inch long, carried down to the bone. These incisions are so planned that the middle portion between them (Fig. 119, B) occupies one-half of the lip. From the lower end of each incision the knife is carried upwards to a point one inch beyond the angle of

the mouth (A). The two flaps thus marked out are freely and deeply dissected up. The alveolar border of the middle portion is then freshened. The lateral flaps (Fig. 120, C A) are now raised, united by sutures in the mesial line, and supported as on a base by the middle flap, to which they are also attached by a few points of suture, leaving a triangular even surface (C C) to granulate. In addition to the division of the cicatrix, James, of Exeter, in these cases very successfully employed a screw-collar, by which the chin can be loosened from the sternum, and gradual extension of the cicatrix effected.

In some cases of burns of the arm in which the sore will not heal, or in which the tense scar renders the limb useless, improvement may be obtained by shortening the limb. Thus, Syme in one case excised the elbow for a burn of the back of the arm which could not be got to heal, and in this way a very useful though shortened limb remained. A portion of the humerus may be removed in the same way, and the ends of the fragments wired together.

Warty Cicatrices.—The cicatrices of burns, especially on the neck and chest, occasionally become after a time projecting, red, and glazed, as if composed of a mass of fungating granulations, smoothed down and thinly skinned over. This condition resembles keloid in appearance, and has been met with chiefly in children; but I have several times seen it in adults, especially in women who had been badly burnt by their dresses taking fire. In these cases I observed, what I have noted in other similar instances in children, that the warty cicatrices were the seat of the most intolerable itching, which no external application seemed to relieve. I have, however, seen the pruritus mitigated by the administration of large doses of liquor potassæ. If small and narrow, these cicatrices may be dissected out; if large, they cannot be removed without risk of much hæmorrhage, for, although fibroid, they are very vascular.

The scars of burns or scalds form the most common seat of this "false" keloid. The cause of this peculiar outgrowth is altogether unknown. It may in some cases, perhaps, be owing to want of care in checking the luxuriance of the granulations; but in other cases it occurs though every attention is paid to the healing of the wound.

The cicatrix of a burn may become the seat of a malignant growth many years afterwards. I have removed a large epithelioma from the cicatrix of a burn, on the forearm of a woman, seventy years after the infliction of the injury, which happened when she was three or four years of age.

Primary Amputation may be required if the burn have destroyed the whole thickness of a limb; the part should then be removed at once, at the most convenient point above the seat of injury. This operation may be required also at a later period, if, on the separation of the eschars, it be found that a large joint has been opened, and is suppurating; or if the disorganisation of the limb be so great as to exhaust the powers of the patient in the efforts at repair. Great caution, however, should be employed in determining on the propriety of primary amputation when the burn has extended, though in a minor degree, to other parts of the body, lest the powers of the patient be insufficient for the double call that will thus be made upon them.

Electric Stroke.—Death from lightning stroke is not a very unfrequent occurrence, and since the introduction of electric lighting several deaths have occurred from accidental contact with wires through which a powerful current

is passing, or with electro-motors. The constitutional symptoms produced are those of shock, which may prove instantly fatal, without any signs of external injury. In other cases, even though the shock has been severe, recovery has followed the employment of artificial respiration and the administration of stimulants. Extensive burns of the clothes and the surface of the body may be produced by lightning; the skin is scorched in broad bands or in narrow lines arranged in an arborescent manner. Fractures of the bones have rarely been recorded. In cases followed by recovery severe pains in the limbs may persist for several days after the injury; and, in several cases recently described in detail by Surg.-Capt. Trask, two still complained of a sense of weakness in the limbs nearly three months afterwards.

The *post-mortem* appearances after death from lightning stroke are not characteristic. *Rigor mortis* is usually well marked; the blood may coagulate imperfectly. The surface of the brain and its membranes are often congested.

FROST-BITE.

When the body has been exposed to severe or long-continued cold, we find, as in the case of burns, that local and constitutional effects are produced.

Local Influence of Cold.—This is manifested chiefly on the extremities of the body, as the nose, ears, chin, hands, and feet, where the circulation is less active than in the more central parts. It occurs to an injurious degree chiefly in very young or aged persons, or in those whose constitutions have been depressed by want of the necessaries of life. In such persons frost-bite and the resulting gangrene are as much due to the feeble vitality of the extremities as to the low temperature to which they are exposed.

The extreme parts of the body, as the feet, more especially the toes, necessarily suffer most frequently, in many cases from long exposure to wet at low temperatures rather than to dry cold. The fingers, the tip of the nose and chin, and the prominences of the cheeks, are especially apt to suffer from dry cold, more particularly when its effects are much increased by high wind; for it is a well-known fact that extremely low temperatures are borne with impunity so long as the air is calm, as, happily, it commonly is in these circumstances. But if a high wind springs up, the heat of the body is so rapidly carried off, that sudden congelation of exposed parts may ensue. It is remarkable how some parts escape. Thus the eyeball is never, to my knowledge, frozen so long as life remains, and yet it might be supposed that the aqueous humour at least would easily congeal. The eyelids, also, thin as they are, commonly escape frost-bite.

The first effect of cold is to cause a contraction of all the involuntary muscular fibres of the part acted on. The small arteries of the skin become so much narrowed that the circulation through the part is completely arrested. It becomes somewhat shrunken and of a dead white colour. In this condition, being deprived of its natural source of heat, it readily becomes frozen if exposed to a sufficiently low temperature. The experience of the production of local anæsthesia by cold teaches us, however, that the tissues may be completely frozen and kept in that state for a minute or more without suffering any injury. If, however, this condition be maintained for a longer time, it is evident that the vitality of the part will be gradually lowered till finally it is completely extinguished. So long as the part is kept bloodless, inflammation

cannot manifest itself; but as soon as the vessels dilate on the restoration of the natural heat of the part, inflammatory phenomena occur varying with the degree of impairment of vitality that the part has suffered during its exposure to cold. If it have been completely killed, the blood fails to enter the vessels of the dead part, which consequently remains white and cold till decomposition sets in. If the damage have been short of this, the blood enters the vessels, and all the phenomena of inflammation are developed. If, from the too sudden thawing of the frozen part, a large quantity of blood be admitted at a high degree of pressure, abundant exudation takes place from the damaged vessels, great swelling and tension ensue, and the circulation may again be arrested, partly by the pressure caused by the exudation, which may extinguish such remains of vitality as are left in the tissues, and partly by the obstruction to the circulation within the vessels from adhesion of the corpuscles. Thus a part which had escaped death from the direct action of the cold may rapidly become gangrenous after a short period of apparent restoration. If it escape gangrene the inflammation gradually subsides, often being accompanied by vesication. If the damage done be still less, the restoration of warmth is followed merely by some redness and possibly a little swelling with much burning pain. The effects of cold, in fact, form one of the best illustrations of the facts that inflammation is the direct result of damage of a part to a degree short of causing death, and that the degree of inflammation is proportional to the extent to which the vitality is lowered.

When gangrene results it is most commonly of the moist variety; the part is swollen and black, finally it becomes dry and shrivelled, and separates by the formation of a line of ulceration around it.

The *Constitutional Effects* of a low temperature need not detain us. It is well known that, after exposure to severe or long-continued cold, a feeling of heaviness and stupor comes on, and gradually creeps on to an overpowering tendency to sleep, which, if yielded to, terminates in coma, and a speedy, though probably painless, death.

Treatment of Frost-Bite.—This consists in endeavouring to restore the vitality of the frozen parts. The great danger is that the circulation may again become arrested, as above described, by the sudden admission of a large quantity of blood at a high degree of pressure. In order to prevent this accident, the temperature must be elevated very gradually and with extreme care. The patient should be placed in a cold room, without a fire, any approach to which would certainly lead to the destruction of the frost-bitten members. These must then be gently rubbed with snow, or with cloths dipped in cold water, and held between the hands of the person manipulating; as reaction comes on, they may be enveloped in flannel or woollens, and a small quantity of some warm liquid or spirit and water may be administered. In this way sensibility and motion will be gradually restored, often with much burning and stinging pain, redness, and vesication of the part. If gangrene have come on, or if sloughing follow the restoration of the circulation, the slough, if of small size, should be allowed to detach itself by the natural process of separation, which should be interfered with as little as possible, the vitality of the parts continuing at a low ebb, and extension of gangrene being readily induced. If the gangrene be extensive, amputation may be required. This should be done at the most convenient situation, as soon as the line of separation has fully formed.

If the person who has been exposed to cold be apparently dead, he must be put in a cold room, the temperature of which must be very slowly raised. Friction, as just described, should be practised, and artificial respiration set up. These means must be continued for a long time, even if no signs of life appear; there being on record instances of recovery after several hours of suspended animation.

Chilblain is a mild form of frost-bite occurring in children and in delicate adults. It occurs on the toes and fingers, and occasionally on other exposed parts, as the nose or ear. It is especially likely to occur in paralyzed or diseased limbs. Most commonly the inflammation does not extend beyond redness and swelling, with burning pain or intense itching. In more severe cases the inflammation of the skin extends to vesication, and occasionally, when the blister bursts, a small slough of the superficial part of the cutis, or in some cases even of its whole thickness, is found beneath. This forms the so-called "broken chilblain."

Treatment.—Very bad chilblains in children, or chilblains of any kind in the adult, are indications of some degree of debility. Healthy exercise, good diet, warm clothing, wash-leather socks, and tonics are useful. Locally, as a preventive, friction with spirits of wine or camphorated oil is useful; in the simple erythematous stage, the application of tincture of iodine is often recommended, or soap liniment to which a little chloroform has been added. Belladonna and soap liniment in equal parts allay the intolerable itching. If a slough forms, boric acid lint or ointment forms a useful application. Unguentum resinæ hastens the healing.

CHAPTER XIII.

INJURIES OF BLOOD-VESSELS.

INJURIES OF VEINS.

VEINS are very commonly wounded suicidally, accidentally, or in surgical operations; but, unless they are deeply seated, injuries of them are seldom attended with any serious consequences. Occasionally subcutaneous rupture or laceration of a vein takes place from a blow or strain. In such cases extensive extravasation of blood will occur, which, however, usually undergoes absorption in a few weeks; but it may suppurate, or the changes described at p. 312 may take place. This accident is most commonly seen in the internal saphenous vein.

There are three sources of danger in open wounds of veins: 1, Loss of Blood; 2, Septic or spreading inflammation of the vein; 3, Entrance of Air into the Circulation.

1. A vein is known to be wounded, when dark blood flows in a rapid and uniform stream from the seat of injury.

The **Hæmorrhage** from a wounded vein may, if the vessel be superficial, be arrested by position, and the pressure of a compress, with a few turns of a roller. A wound of one of the larger veins of the trunk—as of the vena cava, innominate, or iliac—will necessarily prove rapidly fatal from uncontrollable hæmorrhage. When one of the large external veins is wounded, such as the internal jugular, the axillary, or the femoral, it should be fairly exposed and tied with catgut ligature above and below the wound in it. Langenbeck has in this case advised that the companion artery should also be tied. And *a priori* it might be supposed that this would be a wise precaution. But experience and the result of statistical inquiries have alike demonstrated its fallacy. Gross and Morris have shown that the ligature of the internal jugular when wounded in operations about the neck or in suicidal attempts is a very safe procedure, whilst if the common carotid be ligatured at the same time, the mortality following the double operation becomes very high. In the extremities also the simultaneous ligature of the main vein and artery is especially apt to lead to gangrene.

A very small puncture in a large vein may be treated by picking up the wall of the vessel at the injured spot, and applying a ligature, so as to include the opening without completely occluding the vein.

A wound in a vein is closed in different ways according to the size of the opening and the mode of treatment. If the vein be completely divided and a ligature applied, the closure of the vein is brought about in the same way as that of an artery under similar circumstances (see Wounds of Arteries). When a wounded vein is treated by pressure, the lips of the wound come in contact with each other, and union takes place without permanent occlusion of the vessel. If a clot forms above and below the point pressed upon, it is absorbed

and the canal of the vessel restored. At the time when venesection was commonly practised, a patient was often bled many times from the same vein during the course of his life without its becoming occluded.

2. *Septic and spreading inflammation of Veins* will be described when we come to speak of the various forms of venous thrombosis and phlebitis; and 3, the *Entrance of Air into Veins* will be discussed in a subsequent chapter.

INJURIES OF ARTERIES.

Arteries may be bruised, torn, punctured, or cut.

CONTUSION.—A slight bruise of an artery is not attended with any bad consequences; but, if the contusion be sufficiently severe to damage the coats, the artery may become plugged with an adherent clot, and finally occluded. This clot may be deposited gradually, so that the obstruction of the vessel may not be complete till some days after the accident. Thus, a patient was admitted into University College Hospital under Mr. Quain, with a contused wound in the axilla, received in falling upon some iron railings; no change took place in the circulation of the arm for two days, when pulsation in the radial artery ceased, the injured vessel having evidently become plugged by a clot.

RUPTURE AND LACERATION.—An artery may be torn either partially or completely across. When **Partial Rupture** occurs, only the internal and middle coats give way, the toughness of the external coat preventing its laceration. This accident is especially apt to occur in consequence of blows or strains upon diseased or weakened vessels, and may possibly lay the foundation for dissecting and other aneurisms. In other cases, the ruptured portion of the coats becomes turned down into the inside of the vessel, and, acting as a valve, prevents the further progress of the blood through it; more commonly the partially ruptured vessel becomes blocked by a clot adherent to the injured spot. Occlusion of an artery in this way may give rise to gangrene, but as a rule the collateral circulation is sufficient to maintain the vitality of the parts beyond the obstruction. Bowlby has recorded a remarkable case of partial rupture of the subclavian artery resulting from a fracture of the clavicle. The inner and middle coats were cleanly divided at the junction of the first and second parts of the artery, and after being separated from the outer coat in the second part, were driven by the blood-stream into the third part so as completely to occlude it.

A condition of partial rupture may occur in wounds from blunt instruments. Thus, a case occurred at the London Hospital, in which a suicidal wound of the throat had exposed the carotid artery. After death, it was found that the inner and middle coats of the vessel had been divided by the pressure of the knife, which was blunt, but that the external coat had been left entire; and under this was a dissecting aneurism.

The **Complete Rupture** of an artery may occur either in an open wound or under the integuments. When an artery is torn across in an open wound, as in the avulsion of a limb by machinery, or by a cannon-shot, there is usually but little hæmorrhage, even from arteries of the magnitude of the axillary or the femoral, and though the vessel hang out of the wound, pulsating to its very end. The absence of bleeding is owing to the internal and middle coats, which are fragile, breaking off short and contracting

somewhat; while the external coat and the sheath of the vessel, being elastic, are dragged down and twisted over the torn end of the artery, so as completely to prevent the escape of blood (Fig. 121).

When the laceration of the artery is subcutaneous, as occasionally happens in the attempted reduction of an old dislocation of the shoulder, the artery is not as a rule completely torn across, and then either extensive extravasation,

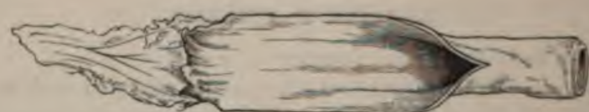

Fig. 121.—Complete Rupture of an Artery.—Vessel laid open. Inner and middle coats broken short, outer coat drawn out.

or one of the varieties of *Traumatic Aneurism*, to be described in Chapter XV., may be produced.

In **Penetrating Wounds** of an artery, there is always hæmorrhage, unless the puncture be so fine as to be closed by the elasticity of the coats of the vessel. Thus, Maisonneuve has shown that an artery may be punctured with a fine needle, without any hæmorrhage resulting. If, however, the puncture be larger than this, being made by a tenaculum or hook, it does not commonly close in this way; and, if hæmorrhage do not take place immediately, it will probably come on in the course of a few days, from ulceration of the vessel. If the wound be still larger, there is always an amount of immediate hæmorrhage proportionate to its size and to that of the vessel.

The *Direction* of the wound in the artery materially influences its characters. If the cut be parallel to the axis of the vessel, there is less tendency to gaping of the edges than if it be oblique. In transverse wounds of arteries, the retraction of the coats is so great as to cause the wound to assume somewhat of a circular appearance. If the artery be cut completely across, there is always less hæmorrhage than when it is partially divided; for the retraction and contraction of the cut ends may then be sufficient to close the vessel, whereas they enlarge the aperture when it is merely wounded. When the wound in the artery is subcutaneous, communicating with the surface only by an oblique and narrow aperture, little, if any, external hæmorrhage takes place, but extravasation of blood occurs. The extravasation may either be poured into one of the serous cavities, or it may be diffused in the areolar tissue of the part, infiltrating it extensively, and perhaps by its pressure ultimately producing gangrene; or it may be effused in a more circumscribed manner, giving rise to one of the forms of traumatic aneurism (see Chapter XV.).

HÆMORRHAGE FROM WOUNDED VESSELS.

LOCAL SIGNS.—The characters of the bleeding or hæmorrhage differ according to the nature of the vessel from which the blood escapes. When a **Vein** is wounded, the blood that is poured out is of a dark colour, and flows in a uniform stream; the force with which this is projected depending on the conditions in which the wounded vein is placed. If there be any pressure

between the wound and the heart, as of a ligature upon the vessel; if the position of the part be such as to favour the gravitation of blood towards the wound; or if the muscles of the limb be made to contract—the force of the flow of blood will be increased.

When an **Artery** is wounded, the blood that escapes is of a bright scarlet colour. It flows in jets synchronous with the contractions of the left ventricle; between the jets the flow does not cease, but the column of blood falls in height. In the great majority of cases the jet comes only from the proximal aperture, dark blood issuing from the distal opening in a continuous and trickling stream; but in some situations a jet of blood of arterial character may issue from the distal as well as from the proximal end of the cut vessel, as in wounds of the palmar and plantar arches, or of the arteries of the forearm. As the blood flows, the jet lessens in height, in consequence of the weakening of the heart's action. The height and force of the jet in all cases depend greatly on the size of the vessel; thus the jet from the femoral artery is stronger than that from a muscular branch of the thigh. When a small arterial branch is wounded near its origin from the main trunk, the jet will always be forcible and free; so also the proximity to the heart will influence materially the force with which the blood is propelled from the wound in the vessel.

Extravasation.—When the blood is not poured out on the surface, but escapes from a wounded vessel into the areolar tissue of a part, the substance of organs, or internal cavities, it is termed an *Extravasation*. In these cases there are not the ordinary local signs of an external hæmorrhage; but other local phenomena, such as swelling, dulness on percussion, displacement of organs or parts, discoloration of the skin and subjacent areolar tissue, indicate that blood is being poured out subcutaneously; and we judge of the quantity of the blood that has escaped, not only by the extent of these local phenomena, but by the general effect produced upon the system by its loss.

CONSTITUTIONAL EFFECTS OF HÆMORRHAGE.—These depend upon the quantity of blood lost, on the rapidity with which it is poured out, and on the state of the patient's constitution.

When a large quantity of blood is suddenly lost, as when a main artery is cut across or an aneurism bursts, the patient may die forthwith; he falls down in a state of syncope, with a pale cold surface and lividity about the lips and eyes, gasps a few times, sighs, is very restless, and suffers convulsive movements of the limbs before he expires. If the quantity lost be not so great as to produce death, though still very considerable, the patient becomes faint and sick, with coldness and pallor of the surface, profuse perspiration, great restlessness and agitation, thirst, noises in the ears, and failure or complete loss of sight. Although the surface of the body is colder than natural, the patient often complains of feeling hot, and throws off the bed-clothes. The respiration is deep and sighing, and one of the most distressing symptoms is a sensation of want of breath. If the quantity lost, though considerable, be not so great as this, or be spread over a greater interval of time, so that the patient is enabled to rally between the recurrences of the hæmorrhage, a state of anæmia will be induced, characterized by pallor of the skin and of the mucous membranes, palpitation of the heart, rushing noises in the head, a tendency to syncope when in the erect position, œdema of the extremities, and general debility.

After excessive loss of blood the patient may gradually rally, and, as the vital fluid is reproduced in his system, he may recover without any bad effects; or he may fall into a state of anæmia, which may perhaps never be completely recovered from, and may be associated with various forms of local debility and disturbance of functions. After very abundant loss of blood, the pulse often assumes a character which has been termed the "hæmorrhagic pulse." Its frequency is greatly increased, the wave of the pulse, as felt at the wrist, is much larger than natural, and dicrotism is usually very marked, the coats of the artery being relaxed from want of tone, and the vessel imperfectly filled. At the same time there may be some slight elevation of temperature. The rallying power is greater in young adults than in old people, and greater in women than in men. Children bear loss of blood badly—a very small hæmorrhage may induce fatal syncope in infants. In advanced life blood is slowly reproduced; and a great loss, whether by accident or in an operation, is seldom completely recovered from, and predisposes to the development of secondary diseases of various kinds. As has already been stated at p. 15, it is in this way that excessive loss of blood at an operation, as for stone in an aged man, may indirectly prove fatal.

Arterial hæmorrhage is, as a rule, more dangerous than venous, as the loss of blood is more rapid and sudden, and the effect produced is proportionally greater. The body of a person who has died from the effects of hæmorrhage presents a peculiarly blanched, semi-transparent, waxen look; the lips, alæ of the nose, and finger-nails, have a somewhat livid appearance, contrasting strongly with the clear, yellowish-white hue of the general surface.

TREATMENT.—The *General Treatment* of hæmorrhage is sufficiently simple. After the flow of blood has been arrested by proper local means, such as will hereafter be described, the effects of its loss are usually speedily recovered from under the influence of rest and good nourishment. In some cases, however, the health becomes permanently impaired, and a state of chronic anæmia is induced, which, notwithstanding the administration of preparations of iron, may continue through life.

When the loss of blood is considerable, it may be necessary to have recourse to immediate measures in order to prevent the syncope from being fatal. With this view the patient should be laid recumbent, with the head low and the limbs raised; pressure may be exercised upon the abdominal aorta or the main arteries of the limbs, or Esmarch's elastic bandage and tourniquet may be applied, so as to confine the blood as much as possible to the head and trunk, and thus maintain a good supply to the brain and lungs. If death appear imminent as happens in some cases of flooding, recourse may be had to transfusion of blood or other fluids; the influence of this, in restoring the failing powers of the heart and nervous system, is immediate and most striking, and its value has been sufficiently proved by the observations of many surgeons and obstetricians.

Operation of Transfusion.—Although there is reason to believe that Transfusion of Blood was not unknown to the ancients, and the method by which it could be performed was distinctly described by Libavius in 1615, little was done in the matter until Sir Christopher Wren, in 1657, proposed and practised the operation of injecting medicated liquids into the veins of animals. Transfusion was first performed on man in France, by Denis and Emmerez, on June 15, 1667. In November of the same year, it was done

in this country by Lower and King. In the early experiments, the blood of sheep and calves was used. The most extravagant ideas were formed as to the utility of transfusion. It was supposed to be capable of curing diseases by substituting the blood of a healthy animal for that of a diseased person, of removing insanity by the injection of the blood of animals of a gentle and docile character into the veins of a maniac, and of prolonging life indefinitely. These pretensions led to a scientific controversy of the most violent kind; and, some deaths having occurred from the practice, partly in consequence of the rude and imperfect instruments used, transfusion was prohibited in France, and fell into disrepute in England. Although the subject was occasionally revived, little attention was paid to it until 1824, when transfusion was again practised by Blundell, who wisely restricted its employment to those cases, chiefly occurring in obstetric practice, in which, in consequence of sudden and profuse hæmorrhage, the patient is threatened with fatal syncope.

The transfusion of defibrinated blood was recommended by Panum, of Copenhagen, in 1863 as a means of diminishing the risk of the introduction of clots into the circulation. According to Bergmann the febrile disturbance which may follow is due to the excess of fibrin ferment set free during coagulation.

The danger of the transfusion of the blood of the lower animals was recognised early in this century. Experiments have shewn that the corpuscles break up rapidly, and that hæmaturia and extensive capillary embolism may result. As a means of preventing the occurrence of embolism, it has been suggested that a mixture of blood and 5 per cent. solution of phosphate of sodium should be used instead of pure blood.

The transfusion of blood was founded on the belief that death from hæmorrhage resulted from a loss of red corpuscles and hæmoglobin. Goltz, however, shewed the fallacy of this view and recognized the important fact that the fatal result is consequent upon an extensive loss of fluid from the vascular system, and thus it became evident that the transfusion of blood, with all its dangers and difficulties, could be replaced by the injection of a sufficient quantity of any suitable fluid, such as a simple saline solution. The present views on this subject were fully expressed by Dr. William Hunter in his lectures at the Royal College of Surgeons in 1889. They are as follows:—first, that the immediate source of danger from sudden loss of blood is the rapid fall of blood pressure; secondly, that the value possessed by transfused blood is almost solely *physical* and dependent upon its volume; and lastly, that all the advantages of transfused blood can be more readily and safely obtained by the use of simple saline solution.

Transfusion is best adapted to extensive and sudden losses of blood from small wounds of large vessels, or from secondary hæmorrhage. It has also proved of the greatest value in obstetric practice. Transfusion after serious surgical operations, such as the removal of large vascular tumours, amputation at the hip, and the like, has seldom proved of material service. The cause of death in such cases is severe shock and not mere loss of blood. The intravenous injection of saline solutions in such cases does, however, seem worthy of further trial, and recently Mayo Robson has recorded two instances in which severe shock following operations not attended with much loss of blood was successfully treated by the intravenous injection of three or four pints of simple saline solution. If transfusion be determined on, it should not be

delayed until the last moment, when the agony of death has already commenced; for then the functions of the nervous and circulatory systems may be so impaired that the patient is beyond recovery, or, if he can be temporarily restored, he will speedily relapse and die.

Transfusion of blood has been carried out directly and indirectly. In the former method a direct communication is established between the vein of the donor and that of the recipient. Aveling's apparatus for this purpose has the great advantage of simplicity; it consists of an india-rubber bulb on the middle of a tube, the ends of which are attached to silver bevel-ended cannulæ inserted into the vein of the donor and recipient respectively. The ingenious apparatus devised by Dr. Roussel, of Geneva, is too complicated to be of much practical use.

Fig. 122.—Apparatus for Intravenous Injection of Saline Solution.

Mediate or indirect transfusion with defibrinated blood has been performed with an ordinary aspirator syringe.

Intravenous Injection of Salt Solution may be performed in the following manner, and ordinary antiseptic precautions should be observed. The solution consists of one drachm of sodium chloride dissolved in one pint of boiled distilled water. A bottle of the form represented in Fig. 122, and large enough to hold two pints, is filled with the solution, and the temperature of the latter is kept at 105° Fahr. by placing the bottle in a vessel of hot water. The median basilic or median cephalic vein is exposed and ligatured at the lower end of the incision. The vein is then opened above the ligature by picking it up with forceps and snipping it half across obliquely with a scalpel or scissors. The cannula is introduced (Fig. 123) and tied with a fine silk ligature. Great care must be taken that the tube and cannula are full of the solution, lest air enter the vein. By slightly raising the bottle the fluid is allowed to flow slowly, and the effect is carefully watched. The amount of fluid required varies greatly in different cases, but between one and two pints is usually sufficient. Very much larger quantities have, however, been used with satisfactory results, and the Surgeon must in each case be guided by the effect produced upon the pulse and the general condition of the patient. In the absence of the apparatus above described, the injection can be performed with a syringe, or with a simple siphon like that used for the nasal douche.

Fig. 123.—Introduction of Cannula into Vein.

CHAPTER XIV.

ARREST OF ARTERIAL HÆMORRHAGE.

The arrest of arterial hæmorrhage is perhaps the most important matter that can engage the Surgeon's attention, for on the accomplishment of this the success of every operation is necessarily dependent. In studying this subject we must first consider the Means adopted by Nature for the Suppression of Hæmorrhage; and, secondly, the imitation of these by Surgical Art.

NATURAL ARREST OF HÆMORRHAGE.

The history of the investigations into the means adopted by nature for the arrest of hæmorrhage is full of interest to the Surgeon, and is excellently given in J. F. D. Jones's work on Hæmorrhage. No subject in surgery affords stronger evidence of the advantage of the application of "Experimental Pathology" to practice than this, as our knowledge of it has been wholly gained by experiments on the lower animals; and by the sacrifice of the lives of a few dogs, donkeys, and calves, those of hundreds—probably of thousands—of human beings are annually preserved.

Petit, who published several memoirs on the subject in 1731 and following years, stated that hæmorrhage was arrested by the formation of two clots—one outside the vessel, which he called the "*Couvercle*," or Cover; the other inside, the "*Bouchon*," or Plug—the former being formed by the last drops of blood that issue, the latter by that within the vessel. These clots, he said, by their adhesion to the internal coat of the vessel and to the orifice stopped the bleeding. When a ligature is applied, a similar clot forms above it. He recommended compression, and the support of the clot.

Morand, in 1736, added much of interest. He admitted the formation of coagula, but insisted on the importance of the changes in the artery itself; which, he showed, became corrugated, contracted, and retracted. Morand entertained erroneous views as to the structure and functions of arteries, but he established the great fact that changes occur in the artery itself. Sharp, in the second edition of his work on Operative Surgery, published in 1739, supported the same doctrine.

Kirkland, in 1763, wrote an excellent treatise on the subject. He showed that hæmorrhage was lessened by swooning, and that an artery contracted up to its nearest collateral branch; and he was of opinion that the coagulum did not arrest the bleeding. His views were adopted and supported by White, Gooch, Aikin, and other surgeons of his day.

J. Bell took a retrograde step by denying the retraction and contraction of the artery, and the importance of the internal coagulum, and by attributing the arrest of hæmorrhage solely to the injection of the surrounding areolar tissue with blood.

It was not until 1805, that Jones, by a series of admirably conducted investigations, finally determined the mode in which the arrest of hæmorrhage takes place.

The *Natural Arrest of Arterial Hæmorrhage* is effected by means that in the first instance are *temporary*, but afterwards *permanent*.

Temporary Means.—The means which temporarily arrest the flow of blood from an artery are threefold. If the vessel be small, as the facial or radial, these means are sufficient in many cases to stay the hæmorrhage without the interference of the Surgeon; and, whatever be the size of the vessel, his operations are materially assisted by the efforts which Nature makes, though they may sometimes be unsuccessful to prevent a fatal escape of blood. They consist in:

1. The Coagulation of, and an Alteration in, the Constitution of the Blood;
2. A Diminution of the Force of the Heart's Action;
3. Certain Changes produced in and around the Artery.

1. The **Coagulation of the Blood** in and around the wounded artery is the most important means adopted by Nature for the arrest of hæmorrhage. Were it not for the property of coagulation, the blood would continue to drain away from any cut artery, however small, until life became extinct. But the coagulation of the blood is sufficient, in all arteries below a certain size, to close the opening in the vessel, and so to arrest the further escape. The *Alteration that takes place in the Blood*, as was first pointed out by Hewson, consists in an increase of its coagulability as it flows.

2. The **Diminution in the Force of the Heart's Action**, owing to the patient becoming faint, exercises a very material influence in arresting the flow of blood from an artery. The forcible manner in which the jet of blood is propelled at each systole of the ventricle, is the principal obstacle to the formation of an adherent blood-clot around and within the cut vessel; for so long as the jet is more powerful than the cohesion of the clot, it will certainly wash the coagulum away. As the blood flows, and the heart's impulse gradually lessens in force, the jet falls lower and lower; until at last, when faintness comes on, it is almost entirely arrested, and time is afforded for the deposit of a coagulum in the vicinity of the wound. The collapse consequent on excessive and sudden loss of blood may therefore be looked upon as one of the provisions of Nature for the safety of the patient, and should not be too speedily counteracted by stimulants or in any other way.

3. The **Changes that take place in and around the Vessel itself** are those upon which the final arrest of the bleeding is dependent. They consist in the *Retraction* of the artery within its sheath, in the *Contraction* of the cut ends, and in the *Formation of a Coagulum* around its exterior, and in its interior.

When an artery is cut across, its longitudinal elasticity causes it immediately to *retract within its sheath*, and at the same time its orifice is narrowed by *the contraction of the muscular fibre cells of the middle coat* in consequence of the stimulation of the mechanical violence. As the artery retracts, the interior of the sheath is left rough and uneven. Through this uneven channel the blood is projected, and as it flows over the roughened surface of the sheath, it ...s entangled in the fibres, and tends to coagulate upon them; this ...y to coagulation is favoured by the increased plasticity of the blood as ..., and by the diminution of the propulsive force with which it is carried

on. By the conjoined operation of these causes a coagulum is formed, which, though lying within the sheath, is outside the artery, and extends beyond it; and is hence termed the **external coagulum**. It is usually somewhat cylindrical, and often looks like a continuation of the vessel, being at first perforated by a hollow track, through which the stream of blood continues to flow. As it increases in size, the track becomes closed by the concentric deposit of coagulum. The hollow track leading from the surface of the coagulum to the wound in the artery, has been especially described and dwelt upon by Amussat. This coagulum acts mechanically by blocking up the end of the artery, and thus constitutes the first barrier to the hæmorrhage.

Simultaneous with the changes that have just been described is the **contraction** of the cut artery which commences immediately after its division, and may of itself be sufficient to close a small vessel. Thus, during an operation, we may often see the mouth of an artery which, when first cut, spouted out a stream of blood as large as a straw, gradually diminish in size until it ceases to bleed, owing simply to this contraction. In a larger artery this process is not sufficient completely to close the vessel, but merely gives its cut end a conical shape and greatly diminishes the aperture in the artery.

The next change that takes place is the formation of the **internal coagulum.** As the open end of the artery becomes obstructed by its own contraction and by the formation of the external coagulum, the blood is propelled with more and more difficulty through it, escaping in a small and feeble stream, and at last becoming completely stationary. Coagulation then takes place within the artery, and the clot that is formed in this situation plays a prominent part in the permanent closure of the vessel. The internal coagulum is conical in form, the base being firmly adherent to the injured coats of the artery at the margin of the aperture and the apex extending upwards. It has no point of attachment except by its base, the apex and sides being perfectly free; at first it consists merely of ordinary blood-clot, but later on, as will be seen hereafter, it undergoes important changes. The importance of the internal coagulum as a temporary means of arresting hæmorrhage, though great, has, I think, been overestimated. In fact it is not formed until the flow of blood has been arrested by the contraction of the artery and the formation of the external clot; and in some cases the proximity of a collateral branch to the cut end of the vessel appears, by preventing the stagnation of the blood, to prevent its formation altogether. When it is formed, it is useful in acting as a damper to break the force of the wave of blood against the cut end of the vessel. The contraction of the artery, being due to the action of the muscular coat, must necessarily cease before long, when relaxation of the muscular fibre-cells takes place; but by this time the vessel is surrounded externally by a coagulum between the sheath and the external coat. This clot having been moulded to the artery in its contracted state prevents the dilatation that would otherwise occur.

After the hæmorrhage from the cut artery has been arrested temporarily by the means that have been indicated, the process of permanent occlusion commences.

PERMANENT CLOSURE of a cut artery is effected by processes analogous to those which have already been described as occurring in the union of wounds in the Chapter on the Process of Repair (p. 286 *et seq.*). During the first few hours after the arrest of the bleeding, the internal coagulum contracts slightly

and becomes more adherent to the inner coat of the artery. For the first twenty-four hours or more the ordinary process of exudation with migration of the white corpuscles takes place, both from the vasa vasorum of the injured artery and from the vessels in the sheath. By the second day therefore we find that the base of the internal coagulum and the external coagulum in the sheath have become paler in colour from infiltration with migrated leucocytes; and exactly opposite the divided end of the artery there may be a small nodule of colourless plastic exudation, composed entirely of small round cells held together by coagulated fibrin. This change therefore corresponds to that which has already been described as occurring in the early stages of union of wounds by first intention, the only difference being in the presence of the great excess of blood-clot. By the end of the first twenty-four or thirty-six hours, if all goes well, the process of the traumatic inflammation and the accompanying exudation resulting from the wound should have ceased, and we then have a firm mass of plastic exudation plugging the mouth of the artery and surrounding its cut extremity externally, and the processes of genuine repair now set in. Outside the vessel these consist merely of the vascularization of the "plastic exudation," the absorption of the blood-clot, and the gradual development of cicatricial fibrous tissue, as already described (p. 288 *et seq.*). It is evident that if these processes go on undisturbed by further inflammation and exudation, the orifice of the wounded vessel is from the first surrounded externally by a firm substance—first, blood-clot; secondly, plastic exudation or "coagulable lymph;" thirdly, firm vascular granulation-tissue; and, lastly, fibrous scar tissue. The artery is therefore sealed externally as well as internally, and these external changes are of equal importance with those about to be described as occurring inside the vessel. If inflammation and suppuration take place in the wound from any cause, more especially if decomposition of the discharges sets in with breaking down of the external coagulum, thus causing the presence of septic matter in immediate contact with the end of the wounded artery, the injured vessel is no longer supported externally, and the safety of the patient will wholly depend upon the changes occurring within the vessel.

We have already seen that soon after its formation the base of the internal coagulum becomes infiltrated with exudation from the vessels of the injured coats of the artery, and consequently becomes paler in tint than the rest of the clot. The internal coagulum gradually extends further from the injured part of the vessel till, as a rule, it reaches the nearest branch above. The next change observed in the clot is that it shrinks slightly. The artery also contracts, firmly embracing the coagulum. The clot now becomes firmly adherent in every part to the inner coat till some difficulty may be experienced in separating it. The contracted vessel usually assumes a conical shape; but in some cases I have seen the contraction commence suddenly, the narrowed part being perfectly cylindrical for about an inch. The next change observable is the *decolorization of the clot.* This commences at the part which is in contact with the injured end of the vessel and gradually extends upwards. The red corpuscles in the clot break up and are absorbed, firm fibrinous plug closely adherent to the inner coat of the artery. s of decolorization is accompanied by still further shrinking of ; is usually completed in about a week. The ultimate changes

consist in a gradual absorption of the internal coagulum, with development of cicatricial fibrous tissue for a greater or less distance from the divided end, the artery being for a corresponding distance converted into a dense fibrous cord. In some cases the complete obliteration of the vessel reaches as high as the next branch; but in others an extremely narrow channel may be found extending some distance into the contracted part of the vessel.

If these processes be followed microscopically in specimens obtained at different periods from animals, the following appearances may be observed: The first exudation which forms at the cut end of the artery and infiltrates the base of the clot differs in no respect from the early exudation in union of a wound by first intention; it is composed of migratory white corpuscles entangled in the meshes of coagulated fibrin. This exudation commences immediately after the injury. By the third day the base of the clot will be more extensively decolorised and the microscope shows that this is due to the growth of new cells which have occupied the place previously filled by the lower part of the clot. The origin of these new cells has been a matter of dispute. Those which infiltrated the base of the clot in the first twenty-four hours are undoubtedly migratory corpuscles; but it seems probable that as soon as the artery has recovered from the damage done it by the wound, growth commences from the endothelial cells of the inner coat. These are described by Cornil and Ranvier as multiplying rapidly and penetrating into the substance of the clot.

The investigations of Ballance and Edmunds give strong support to this view. These observers find that in the carotid of the rabbit proliferation of the endothelial cells can be demonstrated as early as twenty-four hours after the application of a ligature to the vessel. Proliferation was also found to occur in the other connective-tissue cells of the arterial wall; the elastic lamina being eventually broken up by the multiplication and migration inwards of the cellular elements of the middle coat. The coagulum is thus slowly absorbed and replaced by a mass of cells, which are partly migrated leucocytes, but chiefly "plasma-cells" derived from the endothelial and other connective-tissue cells of the arterial wall. By the end of a few days the new tissue replacing the clot is in direct contact with the elastic layers of the inner coat. The mass of cells thus formed is soon penetrated by new vessels springing from the vasa vasorum of the artery at the wounded part. The further course of development is identical with that already described in the chapter on Repair, as occurring in the conversion of vascular "granulation-tissue" into cicatricial fibrous tissue. The final result of the process is that the lumen of the artery for a variable distance becomes filled with fibrous tissue continuous with the coats of the vessel. The development of the cicatricial tissue from the granulation-tissue is necessarily accompanied by considerable contraction, while at the same time the muscular coat atrophies from want of use; and thus after some weeks or months the end of the artery becomes converted into a thin cord of fibrous tissue, which is finally lost in the scar of the external wound.

This development of fibrous tissue in the site of the clot has been described as "organisation of the thrombus." This term is, however, somewhat misleading; and it must be clearly understood that, according to the views held by modern pathologists, the thrombus takes no more share in the production of the fibrous tissue than does the layer of blood-clot which cements together the

After excessive loss of blood the patient may gradually rally, and, as the vital fluid is reproduced in his system, he may recover without any bad effects; or he may fall into a state of anæmia, which may perhaps never be completely recovered from, and may be associated with various forms of local debility and disturbance of functions. After very abundant loss of blood, the pulse often assumes a character which has been termed the "hæmorrhagic pulse." Its frequency is greatly increased, the wave of the pulse, as felt at the wrist, is much larger than natural, and dicrotism is usually very marked, the coats of the artery being relaxed from want of tone, and the vessel imperfectly filled. At the same time there may be some slight elevation of temperature. The rallying power is greater in young adults than in old people, and greater in women than in men. Children bear loss of blood badly—a very small hæmorrhage may induce fatal syncope in infants. In advanced life blood is slowly reproduced; and a great loss, whether by accident or in an operation, is seldom completely recovered from, and predisposes to the development of secondary diseases of various kinds. As has already been stated at p. 15, it is in this way that excessive loss of blood at an operation, as for stone in an aged man, may indirectly prove fatal.

Arterial hæmorrhage is, as a rule, more dangerous than venous, as the loss of blood is more rapid and sudden, and the effect produced is proportionally greater. The body of a person who has died from the effects of hæmorrhage presents a peculiarly blanched, semi-transparent, waxen look; the lips, alæ of the nose, and finger-nails, have a somewhat livid appearance, contrasting strongly with the clear, yellowish-white hue of the general surface.

TREATMENT.—The *General Treatment* of hæmorrhage is sufficiently simple. After the flow of blood has been arrested by proper local means, such as will hereafter be described, the effects of its loss are usually speedily recovered from under the influence of rest and good nourishment. In some cases, however, the health becomes permanently impaired, and a state of chronic anæmia is induced, which, notwithstanding the administration of preparations of iron, may continue through life.

When the loss of blood is considerable, it may be necessary to have recourse to immediate measures in order to prevent the syncope from being fatal. With this view the patient should be laid recumbent, with the head low and the limbs raised; pressure may be exercised upon the abdominal aorta or the main arteries of the limbs, or Esmarch's elastic bandage and tourniquet may be applied, so as to confine the blood as much as possible to the head and trunk, and thus maintain a good supply to the brain and lungs. If death appear imminent as happens in some cases of flooding, recourse may be had to transfusion of blood or other fluids; the influence of this, in restoring the failing powers of the heart and nervous system, is immediate and most striking, and its value has been sufficiently proved by the observations of many surgeons and obstetricians.

Operation of Transfusion.—Although there is reason to believe that Transfusion of Blood was not unknown to the ancients, and the method by which it could be performed was distinctly described by Libavius in 1615, little was done in the matter until Sir Christopher Wren, in 1657, proposed and practised the operation of injecting medicated liquids into the veins of animals. Transfusion was first performed on man in France, by Denis and Emmerez, on June 15, 1667. In November of the same year, it was done

in this country by Lower and King. In the early experiments, the blood of sheep and calves was used. The most extravagant ideas were formed as to the utility of transfusion. It was supposed to be capable of curing diseases by substituting the blood of a healthy animal for that of a diseased person, of removing insanity by the injection of the blood of animals of a gentle and docile character into the veins of a maniac, and of prolonging life indefinitely. These pretensions led to a scientific controversy of the most violent kind; and, some deaths having occurred from the practice, partly in consequence of the rude and imperfect instruments used, transfusion was prohibited in France, and fell into disrepute in England. Although the subject was occasionally revived, little attention was paid to it until 1824, when transfusion was again practised by Blundell, who wisely restricted its employment to those cases, chiefly occurring in obstetric practice, in which, in consequence of sudden and profuse hæmorrhage, the patient is threatened with fatal syncope.

The transfusion of defibrinated blood was recommended by Panum, of Copenhagen, in 1863 as a means of diminishing the risk of the introduction of clots into the circulation. According to Bergmann the febrile disturbance which may follow is due to the excess of fibrin ferment set free during coagulation.

The danger of the transfusion of the blood of the lower animals was recognised early in this century. Experiments have shewn that the corpuscles break up rapidly, and that hæmaturia and extensive capillary embolism may result. As a means of preventing the occurrence of embolism, it has been suggested that a mixture of blood and 5 per cent. solution of phosphate of sodium should be used instead of pure blood.

The transfusion of blood was founded on the belief that death from hæmorrhage resulted from a loss of red corpuscles and hæmoglobin. Goltz, however, shewed the fallacy of this view and recognized the important fact that the fatal result is consequent upon an extensive loss of fluid from the vascular system, and thus it became evident that the transfusion of blood, with all its dangers and difficulties, could be replaced by the injection of a sufficient quantity of any suitable fluid, such as a simple saline solution. The present views on this subject were fully expressed by Dr. William Hunter in his lectures at the Royal College of Surgeons in 1889. They are as follows:—first, that the immediate source of danger from sudden loss of blood is the rapid fall of blood pressure; secondly, that the value possessed by transfused blood is almost solely *physical* and dependent upon its volume; and lastly, that all the advantages of transfused blood can be more readily and safely obtained by the use of simple saline solution.

Transfusion is best adapted to extensive and sudden losses of blood from small wounds of large vessels, or from secondary hæmorrhage. It has also proved of the greatest value in obstetric practice. Transfusion after serious surgical operations, such as the removal of large vascular tumours, amputation at the hip, and the like, has seldom proved of material service. The cause of death in such cases is severe shock and not mere loss of blood. The intravenous injection of saline solutions in such cases does, however, seem worthy of further trial, and recently Mayo Robson has recorded two instances in which severe shock following operations not attended with much loss of blood was successfully treated by the intravenous injection of three or four pints of simple saline solution. If transfusion be determined on, it should not be

thumb. Thus, in amputation at the hip or shoulder joint, the assistant readily controls the rush of blood from the femoral or axillary artery by grasping them between his fingers. Above all, the Surgeon should never dread hæmorrhage, nor lose his presence of mind when it occurs. If recourse be had to proper means, it can always be, at least temporarily, arrested. On no account should anyone who pretends to the character of a Surgeon employ inefficient means to stop it, and imagine that he can, by covering up the wound with rags, handkerchiefs, &c., prevent the escape of blood. These procedures only hide the loss that is going on, and, by increasing the warmth of the parts, prevent the contraction of the vessels, and favour the continuance of the bleeding. Under all circumstances, therefore, bleeding wounds should be opened up, the coagula gently removed from their surface by means of a piece of soft sponge or a stream of cold water, and the part well cleaned. In this way "you look your enemy in the face," and can adopt efficient means for the permanent arrest of the hæmorrhage.

The methods of controlling the flow of blood temporarily by digital compression and by the various forms of tourniquet have been fully described on p. 45 *et seq.* It is usually necessary to have recourse to some of these during the application of means intended to produce permanent arrest of the bleeding. The screw tourniquet and digital compression will usually be found the most convenient, as the pressure can be rapidly relaxed, in order to guide the Surgeon to the bleeding-point, and reapplied if necessary.

The different means that may be employed for the *permanent* arrest of hæmorrhage are: 1, The Application of Cold; 2, the Application of Hot Water; 3, Styptics; 4, Cauterisation with a Hot Iron; 5, Pressure; 6, Flexion; 7, Torsion; 8, Forcipressure; 9, Ligature; and 10, Acupressure.

1. Application of Cold is sufficient to arrest the general oozing of arterial blood which is always observed on a cut surface. The mere exposure to the cold air of a wound, which has bled freely so long as it has been covered up by pledgets and bandages, is often sufficient. When this does not succeed, the application of a piece of lint, soaked in cold water, will usually arrest the flow of blood. In cases of bleeding into some of the cavities of the body, as the rectum, vagina, or mouth, the application of ice is advantageous. Its use should not, however, be too long continued, lest sloughing occur. Indeed, if cold do not speedily arrest the bleeding, it is better to have recourse to more efficient means.

2. The Application of Hot Water is a most valuable means of arresting oozing during or immediately after an operation. It is especially useful in operations about the face and trunk in which it is impossible to adopt any bloodless method of operating, and yet in which it is important that the view of the operator should not be obscured by persistent oozing of blood. It immediately arrests the free bleeding from small vessels which follows the removal of Esmarch's bandage. This mode of treatment was introduced in America in 1879 by Hamilton, Brown, and Hunter. Hamilton applied water at a temperature of between 150° F. and 160° F., by means of sponges held in forceps. Brown recommended washing the whole wound with water of the same temperature. Hunter applied the water at a lower temperature, 125° F. to 130° F., which can just be endured by the Surgeon's hands. All these plans act very well, and although the heat is sufficient to whiten the surface of a divided muscle, no evil consequence results, and union by first intention is

not interfered with. If the wound is being treated antiseptically, a hot solution of carbolic acid (1 in 40), or two teaspoonfuls of tincture of iodine added to a pint of water, may be used instead of the simple hot water. Care must be taken in employing this method of arresting hæmorrhage, that the water used be sufficiently hot, otherwise the effect will be merely to increase the bleeding.

Some very interesting observations by Milne Murray have clearly shown the superiority of hot water to cold in inducing contraction of involuntary muscular fibre. They may be briefly summarised as follows: After the application of cold, there is a very distinct latent period, and contraction develops slowly, while hot water at a temperature of 110° F. to 120° F. gives rise to almost immediate contraction rapidly developed. Successive applications of cold induce contraction only after a period of rest, and the contractions become diminished in efficiency; successive applications of heat, on the other hand, are followed by immediate contraction, and the efficiency of the contraction is increased rather than diminished. Continuous application of cold produces rapid exhaustion, the muscular fibre becoming completely relaxed and failing to respond, while heat induces a high degree of contraction, broken by periods of partial relaxation followed again by contraction. In Murray's experiments the uterus of the rabbit was chiefly used, but there is no doubt the results may be applied equally to the muscular tissue of arteries.

3. STYPTICS are substances which cause contraction of the vessels and coagulate the albumen of the blood, thus increasing the rapidity of formation and the firmness of the coagulum. They are used principally in oozing from spongy parts, or in bleeding from cavities or organs to which other applications cannot readily be made. The great objection to their employment in some wounds is their tendency to modify injuriously the character of the surface and to prevent union by the first intention. The most useful styptics are the solution of perchloride of iron, spirits of turpentine, and gallic or tannic acid; the application of alum, or touching a bleeding part with a pointed stick of the nitrate of silver, is also serviceable. Of all these, the solution of the perchloride of iron is that most commonly used, and it is undoubtedly a most powerful hæmostatic, but it acts very injuriously on the wound. The black hard clot it forms with the blood is very efficient in arresting the bleeding, but is slow to come away and delays healing. Turpentine is a most valuable styptic. It was formerly much used, and is now too much neglected. It is antiseptic and does little damage to the surfaces of the wound. It should always be tried when possible before using the perchloride of iron. In some cases tincture of hamamelis (ʒj. or ʒij. to ℥j.) will be found an efficient hæmostatic. *In order to apply any styptic effectually, the wound should be thoroughly cleaned, and all coagula removed.* A piece of lint or absorbent cotton-wool, or a sponge squeezed as dry as possible, is then firmly pressed on the bleeding spot by an assistant, or by the Surgeon with his left hand, while another piece of lint or cotton-wool is soaked in the styptic solution, and then squeezed nearly dry. The piece of dry lint or sponge is rapidly removed from the wound with the left hand, and the styptic instantaneously applied with the right before the surface has had time to get wet with blood. It may then be maintained in position by the pressure of the finger or of a pad and bandage. When the hæmorrhage is from a cavity and the actual bleeding point cannot be seen, the styptic solution may be injected by means of a

syringe, or, in some cases, if it proceed from a mucous canal, this may be firmly plugged with lint soaked in the styptic solution.

Wright has suggested the use of what he calls a "physiological styptic." It consists of an extract of calf's thymus with a weak solution of carbonate of soda, to which 1 per cent. of chloride of calcium is added. The active agent is Wooldridge's tissue fibrinogen.

4. Cauterisation by means of the red-hot iron was the mode of arresting arterial hæmorrhage most used by the ancients and in the Middle Ages. It is now comparatively seldom employed, and should never be made use of when less severe measures are likely to succeed. Yet in some cases it is of great utility, and superior to any other means that we possess; more particularly when the hæmorrhage proceeds from a soft and spongy part that will not hold a ligature, or on the surface of which many points appear to be bleeding at the same time. A somewhat conical iron of sufficient size should be used, and the hæmorrhage will often be checked more effectually if it be applied at a black than at a red or white heat. The bleeding surface must be carefully dried by the pressure of a sponge or of dry cotton-wool before the cautery is applied, otherwise its action is extremely uncertain. It is most useful, perhaps, for the arrest of capillary hæmorrhage from sloughing wounds, but arteries of moderate size may thus be closed. As the actual cautery blocks up the artery with a thick slough or eschar (Fig. 124), there is always some danger of a recurrence of the bleeding when this separates, and the Surgeon must be on his guard about the sixth or eighth day lest the hæmorrhage break out afresh.

Fig. 124.—A fresh Artery from the dead body, cauterized—showing the firm adherent eschar.

In some cases, however, in which the cautery has been applied to the cut end of an artery removed from a fresh dead body, it has been found that the eschar is formed of the external coat only, the inner and middle coats being separated and turned up into the lumen of the artery. This result, however, does not seem to be constant.

The actual cautery has frequently been employed of late years during operations on very vascular parts in which temporary arrest of the circulation is impossible. It has been used chiefly in two forms: first as the galvanic écraseur, and secondly as a red-hot knife. The galvanic écraseur is simply a loop of platinum-wire which can be heated by electricity after being passed round the part to be removed. During the operation the loop is gradually tightened, by means of a screw in the handle of the instrument, until the part is removed. Operations performed in this way are almost bloodless; but the instrument, with its battery, is very cumbersome, its action is not certain, and secondary hæmorrhage is common after its use; consequently it is now but little employed except for the removal of nasal polypi and other small pedunculated growths. Its place has been taken in larger operations by Paquelin's red-hot knife. This is a flattened hollow blade with blunt edges, made of platinum, and fixed on a handle connected by an india-rubber tube with a bottle containing benzol. The knife is first made red-hot in a spirit lamp, and its heat is maintained by blowing a mixture of air and benzol-vapour into the hollow blade by means of an elastic ball. The benzol-vapour burns without flame, and the heat can be maintained at any point that is required by driving in a larger or smaller amount of vapour. Care must be taken not to allow any of the liquid benzol

to get into the tube, or a flame would flash from the instrument; this is best avoided by filling the bottle with pieces of sponge. The blade can be replaced if necessary, by cauteries of various shapes. In removing very vascular growths, such as an epithelioma of the vulva, the knife, if at a glowing red heat, arrests the flow of blood from the smaller vessels only, leaving the larger arteries spouting from a perfectly dry surface, and they can thus be seized and tied without difficulty, or, if preferred, touched with the cautery at a dull red heat. The surface left is very superficially charred, and heals with little or no sloughing. If it be desired to arrest the flow of all vessels completely, the knife must be used at a dull red heat; it then cuts more slowly and chars more deeply.

5. Direct Pressure upon the bleeding part is a very efficient mode of arresting hæmorrhage from small arteries. It is not, however, equally applicable to all parts of the body. It can be most readily applied when the vessel has a bone subjacent to it, so as to afford a point of counterpressure, and it cannot be so readily employed in soft and movable parts, as the throat or perinæum. Pressure may be practised in various ways. Sometimes the uniform compression of a bandage is sufficient; thus oozing from an amputation wound may often be stopped by laying down the flaps and applying a bandage firmly over them. In the cotton-wool dressings the elastic pressure is of great use in arresting oozing. In the case of bleeding from hollow cavities, as the rectum, vagina, or nares, the hæmorrhage may be arrested by the pressure of a plug of sponge or lint, to which sometimes a styptic may advantageously be added. When the hæmorrhage proceeds from the puncture of a small or moderate-sized artery, as the temporal, pressure should be made against the subjacent bone by means of a graduated compress and bandage, and should be continued until a sufficient time has elapsed for the vessel to be firmly plugged on each side by an adherent coagulum. The *graduated compress* should be at least an inch in thickness, and made of a series of pledgets of lint of a circular shape, gradually diminishing in size. It should be applied with its pointed end resting over the wound in the vessel. Care should be taken that the part on which the pressure is to be exercised has been thoroughly dried of all blood, and that the artery is commanded on the proximal side of the wound by a tourniquet or by the pressure of an assistant's finger. A thick slice of a phial-cork, or a threepenny piece, wrapped in lint, being placed on the wound, the graduated compress should be bandaged tightly over the whole. When applied in this way, pressure acts by encouraging the formation of an adherent clot on each side of the part of the vessel closed by the force applied. The subsequent changes are the same as those already described as occurring after spontaneous arrest of bleeding (p. 414).

Whenever pressure is used to arrest arterial bleeding, it must not be forgotten that the whole area pressed upon is rendered absolutely bloodless. We have before seen (p. 175), that if a part be deprived of blood for a sufficient time—probably in the human subject for between twelve and twenty-four hours—the readmission of blood is accompanied by all the phenomena of acute inflammation, the intensity of the process varying with the length of time during which the part has been kept bloodless; and we are all of course familiar with the fact that, if the pressure be applied with sufficient force for a sufficient length of time, death of the part must follow. It is very important, therefore, that pressure should not be applied for a single hour longer than

is necessary to ensure the safe plugging of the wounded artery by an adherent clot. The experience of acupressure has shown us that in a small artery—and it is, of course, only to small arteries that pressure is applied as a means of arresting hæmorrhage—about twelve hours is a sufficient time to ensure the closure of the vessel. *A graduated compress should, therefore, not be kept firmly applied for more than twelve hours;* at the end of that time the bandages should be removed and loosely reapplied without disturbing the compress, which will be sticking to the part, after which the patient must be kept very quiet with the limb raised if the wound be in one of the extremities. The inflammation or sloughing produced by excessive and prolonged pressure is the cause of the frequency with which arrest of bleeding by pressure is followed by secondary hæmorrhage.

In employing pressure, it must be borne in mind also that, *if applied accurately to the mouth of the bleeding vessel, the actual force required to stop the flow of blood is very small.* In the palmar arch, for instance, less than a quarter of an ounce accurately applied would close the mouth of the artery.

6. FORCIBLE FLEXION, as a means of arresting hæmorrhage from the arteries of the limbs, has in recent years been advocated by Heath of Newcastle, Adelmann of Dorpat, and others. Its application is founded on the fact, specially pointed out in 1843 by Formey, that flexion of the arm at the elbow-joint weakens or arrests the pulsation at the wrist. Malgaigne, Vidal, Fleury, Fry, and some other Surgeons, have reported cases in which the plan was employed successfully; but until lately the method has attracted little attention. Heath, from a number of experiments made by him in the Newcastle Infirmary, has found that flexion of the arm at the elbow, or of the leg at the knee, diminishes or arrests the pulse in the arteries beyond. In this respect he confirms the observations of Hyrtl and others; but he finds also that in the arm the process is greatly aided by placing a piece of lint or a handkerchief rolled up in the bend of the elbow; and in the lower limb, by bending the thigh on the abdomen at the same time that the leg is bent at the knee. Where flexion acts successfully as a means of hæmostasis, as it is reported to have done in several cases—especially in wounds of the palmar arteries and the vessels of the forearm—it probably does so by weakening the current of blood, so as to favour the closure of the arterial wound in the manner described in speaking of the Natural Arrest of Hæmorrhage. The apparent simplicity and safety (when carefully applied) of flexion render it worthy of further trial in cases of injury of the arteries of the forearm and hand, or of the leg and foot. A roll of lint or other soft material having been placed in the flexure of the joint, the limb should be bent until it is perceived that the hæmorrhage is arrested, and should then be maintained in position by means of a handkerchief or bandage. Care must of course be taken not to exercise too great compression, by which gangrene might be produced. The flexion should be kept up till the Surgeon, by careful examination, is satisfied that there is no further risk of hæmorrhage.

7. TORSION OF CUT ARTERIES for the arrest of hæmorrhage is mentioned by Galen; but the practice seems to have been forgotten until about 1828. It was revived in France by Amussat, Velpeau, and Thierry; and in Germany by Fricke, but notwithstanding the efforts made to force it on the attention of Surgeons, it was gradually abandoned, even by its strongest advocates.

Torsion has never come into general use, and has certainly been too much neglected, even in this country, where it has been more commonly adopted than elsewhere. It may be practised in various ways. Amussat recommended that the artery be drawn out for about half an inch with one pair of forceps; that it then be seized close to the tissues with another forceps, and that the end then be twisted off (Fig. 125). This plan was applicable only to the larger arteries, which could be cleanly isolated from the surrounding tissues. Thierry simply seized the artery and twisted it in the direction of its axis, and this plan is undoubtedly most effectual, as the second pair of forceps prevents the inner and middle coats from being properly turned up into the lumen of the vessel. Velpeau and Fricke advised that the end be

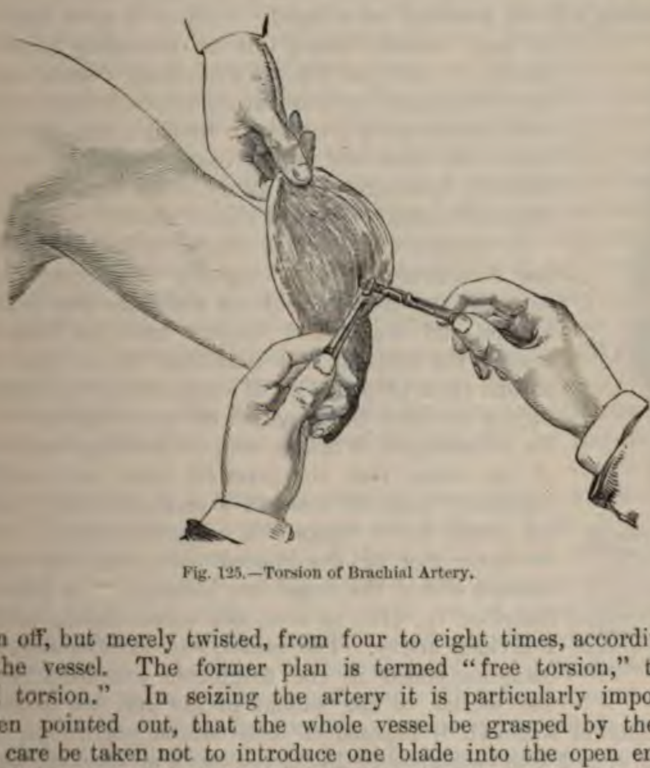

Fig. 125.—Torsion of Brachial Artery.

not taken off, but merely twisted, from four to eight times, according to the size of the vessel. The former plan is termed "free torsion," the latter "limited torsion." In seizing the artery it is particularly important, as Dupuytren pointed out, that the whole vessel be grasped by the forceps, and that care be taken not to introduce one blade into the open end of the vessel, and thus twist only half of it. Hæmorrhage from the largest vessels may be effectually stopped by torsion. Amussat and Velpeau repeatedly used it to close the femoral, brachial, ulnar, and radial arteries in amputations of the thigh, arm, and forearm; and more recently Cooper Forster and Bryant at Guy's Hospital, and Callender at St. Bartholomew's, have used it successfully as the only means of arresting arterial hæmorrhage after operations. Their experience shows that, to say the least, torsion is as safe as any other mode of occluding a wounded artery.

In order to apply torsion successfully, a strong pair of forceps, with accurately fitting serratures, must be used (Fig. 126), and the width of the blades should vary with the size of the artery to be twisted. In applying

torsion to a large vessel, it is better not to twist the end completely off; three or four sharp turns usually suffice, during which the inner and middle coats are felt to give way and all resistance to cease. Smaller vessels may be

Fig. 126.—Torsion-forceps.

twisted till the part included in the forceps comes off. Even with small vessels it will be found that the more cleanly the vessel can be isolated the more certainly will the bleeding be stopped. Torsion is most easily applied to large vessels, which can be accurately seized in the forceps; it is most difficult with small vessels, especially if they are situated in dense structures, or in tissues infiltrated with inflammatory products. Bryant states that degeneration of the inner and middle coats in no way increases the difficulty in securing the artery, fewer turns in fact being required to close a diseased than a healthy vessel.

Fig. 127.—A Femoral Artery from a fresh dead body, twisted freely and laid open. The inner and middle coats are turned up into the lumen of the vessel for half-an-inch.

In torsion an artery is placed in the condition of one that is lacerated or torn through. The inner and middle coats are ruptured immediately above the part seized in the forceps, and are turned upwards into the lumen of the vessel; the external coat is twisted into a kind of screw beyond them (Fig. 127). If a large vessel be treated in this way in the dead body and cut off about half an inch above the twisted part, it can be seen by looking down the lumen of the vessel that the inverted inner and middle coats completely close the vessel in a manner roughly resembling the closed aortic valves. A coagulum forms, adherent at its lower end to the injured coats, and the subsequent changes within the vessel are identical with those already described (p. 414) as occurring in permanent occlusion of a divided artery. The twisted end becomes absorbed after being embedded in the coagulable exudation that unites the surface of the wound in the first few hours, but it may separate as a slough if exposed to unfavourable conditions, as in an ill-drained wound with decomposing discharges, or on an open surface.

Torsion and Ligature Compared.—The employment of torsion as a substitute for the ligature is advocated on three grounds: 1, that, whilst equally safe, it is more easy of application; 2, that it is less likely to be followed by secondary hæmorrhage; and 3, that when an artery is closed by torsion, no foreign body is left in the wound that could interfere with its direct union.

Let us briefly examine the advantages claimed for torsion over the ligature.

1. As far as ease of application is concerned, there can be no doubt that the advantage is in favour of the ligature. This is very markedly the case with small vessels and those that cannot be drawn out of their sheaths. In the case of the larger arteries, that can be denuded and drawn out of the neigh-

bouring tissues, it is at least as easy to ligature the vessel as to twist it efficiently.

2. With reference to the comparative freedom from secondary hæmorrhage, we have few data; but all those Surgeons who have extensively employed torsion agree in stating that it is very rarely followed by secondary hæmorrhage. The same may, however, be said with equal truth of the ligature as used at the present time.

3. The torsion of arteries was strongly advocated on the ground that, whilst quite as safe as the ligature, there would after its employment be less liability to inflammation and suppuration, as no foreign body was left in the wound. This argument was used especially by Amussat; Manec and others maintained that the twisted end, of a large artery at any rate, is in reality a foreign body. At the present day, when the treatment of wounds is so much better understood than it was in their time, these arguments are of but little practical importance. We know that a piece of dead tissue, the size of the twisted end of an artery, becomes speedily buried in the exudation that forms during the first twenty-four hours after the infliction of a wound, provided that the cavity is properly drained, and the surfaces brought accurately together and kept at rest; and that under these circumstances it is readily absorbed without causing inflammation or suppuration. In fact, it acts as an irritating foreign body only when it remains uncovered and undergoes decomposition. The same is true of the ligatures in common use at the present day. On the other hand, the old silk ligature, the ends of which were left hanging out of the wound, infallibly acted as an irritant, and excited suppuration in its track. Torsion, therefore, undoubtedly presents advantages over the old silk ligature, and is equally safe and no more likely to interfere with primary union than an absorbable ligature. The latter possesses, however, the advantage of much greater ease of application, and is therefore preferred by the majority of Surgeons.

8. Forcipressure is a mode of arresting hæmorrhage which has been recommended as of use in certain cases by Spencer Wells, Koeberlé, and Péan. It consists in seizing the end of the vessel in a pair of forceps having strong short blades somewhat deeply serrated, and long scissor handles provided with a catch (Fig. 128). The forceps can be closed with sufficient force to crush the end of the vessel between the blades. The form of forceps represented in the figure is that invented by Spencer Wells, which is certainly the most convenient and efficient. The use of these forceps as a temporary means of arresting hæmorrhage has already been alluded to. When used in this way it will frequently be found that, on relaxing their hold after a few minutes, no bleeding takes place. Under these circumstances, experience shows that the closure of the vessel is as safe as that effected by torsion. Should the Surgeon wish to make the arrest of bleeding still more certain, he may give the forceps a few turns while removing them, and thus apply torsion. Forcipressure is occasionally useful in deep wounds in which a ligature cannot be applied. In these cases, in order to make the closure of the vessel more certain, the forceps may be left in the wound for twelve or twenty-four hours and then carefully removed.

9. Ligature is the means to which Surgeons commonly have recourse for the arrest of hæmorrhage from wounded arteries.

The Ligature was undoubtedly employed to a considerable extent by the

later Roman Surgeons, and is frequently mentioned by Celsus. With the decline of Surgery during the dark ages it fell almost completely into disuse, giving way to such barbarous and inefficient means as the employment of the actual cautery, the performance of operations with red-hot knives, or the application of boiling pitch or molten lead to the freshly-cut surface. It seems, however, never to have been altogether abandoned. Almost every surgical writer of any importance from the time of Celsus to the sixteenth century mentions the ligature, and most recommend its use in accidental wounds of large vessels. It was only in amputations that the rule was absolute to use the cautery, and this, as Paré tells us, was "not only to stay the flux of blood, but chiefly to correct the malignity or gangrenous putrefaction which might spoil the neighbouring parts." To what extent the ligature was used before the sixteenth century it is difficult to determine, but that it was a recognised mode of treatment of hæmorrhage is clear. In 1552 Ambroise Paré, Surgeon to the King of France, first practised the application of the ligature to the divided vessels in amputations, and advocated its use under all possible circumstances as the safest and most painless method of arresting arterial hæmorrhage. But so slowly did the ligature make way, that Sharpe, Surgeon to Guy's Hospital, writing in 1761, two centuries after its reintroduction by Paré, found it necessary, in his well-known work, entitled "A Critical Enquiry into the Present State of Surgery," formally to advocate its employment for the arrest of hæmorrhage from wounded arteries, in preference to styptics or the cautery, on the ground that "it was no as yet universally practised amongst Surgeons residing in the more distant counties of ou kingdom." What, it may be asked, was th reason that it took two centuries to promulgat the use of this simple and most efficacious means for the arrest of hæmor rhage? The reason simply was, that Surgeons were totally ignorant of th means employed by Nature for the occlusion of arteries; that they conse quently did not know how to apply a ligature to these vessels, or what kind o ligature should be used; and that, in their anxiety to avoid the occurrence o secondary hæmorrhage, and to make all safe, they fell into the very errors the would have endeavoured to avoid, had they been acquainted with the natur of the processes by which the closure of the artery and the separation of th ligature are effected.

Fig. 128.—Forcipressure forceps.

Between twenty and thirty years after the time at which Sharpe wrote Hunter introduced that great improvement in the surgical treatment o aneurism—the deligation of the artery at a distance from the sac, and in healthy part of its course; but this great advance in the treatment of a mos form … was but coldly received, and ran some risk of being lost t … quence of the ill-success that attended the earlier operation … operation, four ligatures were used, each of which wa

applied so slackly as merely to compress the artery, in order to avoid too great a degree of pressure at any one point; and the artery was denuded, so that a spatula could be passed under it. Although in his subsequent operations Hunter contented himself with employing but one ligature, yet sometimes the vein was included in this; and he did not draw the noose tight for fear of injuring the coats of the vessel, in accordance with the doctrine of the day—Surgeons generally at this time being haunted by the dread of injuring, and thereby weakening, the coats of the artery; and, in order to avöid doing so, they adopted modes of treatment that almost infallibly led to ulceration of the vessels and consecutive hæmorrhage. The employment of several ligatures of reserve, applied slack, the use of broad tapes, the interposition of plugs of cork, wood, agaric, or lead, or of rolls of lint or plaster, between the thread and the vessel, were some amongst the plans that were in common use. And how can we be surprised that the patients perished of hæmorrhage, and that

Fig. 129.—End of Artery drawn forwards. Application of Ligature.

ligature of the vessel was nearly as inefficient and fatal a means of arresting bleeding as the use of a cautery, or of a button of white vitriol?

Jones, by a series of admirably conducted investigations on living animals, showed that the very point which Surgeons were anxious to avoid—the division of the coats of the vessel by the tightening of the noose—was that on which the patient's safety depended; he also pointed out the form and size of ligature that was most safe, the degree of force with which it should be applied, and the processes adopted by Nature for the occlusion of the vessel. Thus a more rational practice was introduced, and then, for the first time, Surgeons had full confidence in the use of the ligature.

Application of the Ligature.—The mode of application of the ligature varies according as (1) the cut end of the artery has to be tied in an open wound, or as (2) the vessel has to be secured in its continuity.

1. When the **divided vessel in an open wound** has to be tied, as after an amputation, the mouth of the artery must be seized and drawn forwards (Fig. 129). For this purpose a tenaculum, or sharp hook, was formerly used, and answered the purpose very well. There were, however, objections to this

instrument: thus, it occasionally seized other tissues with the artery, and, occasionally, an accidental puncture having been made by it behind the part of the vessel to which the ligature was applied, ulceration and subsequent fatal hæmorrhage ensued, as I have seen in one case. The most convenient instrument for the purpose of drawing forward the artery, and one to which ... applies, is Liston's "bull-dog" forceps. These have been ... by having the blades expanded just above the points ... ligature can be slipped over their end on to an artery ... between bones or close to the interosseous membrane ... in which it is sometimes troublesome to tie a vessel by ...

... ligature, care must be taken that it be put well over the cut ... clear the points of the forceps, and that it be tied ... which will not slip (Fig. 131). As the knot is ... the forefingers should be in close contact with the points ... pressed slightly downwards on the artery, otherwise the ... forwards out of its bed, or the forceps pulled off it. In

... Bull-dog" Forceps, modified.

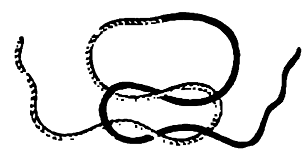

Fig. 131.—The Ligature, or reef-knot.

... bleeding point may be so situated, that the ligature is most ... passed round it by means of an ordinary curved needle.

... artery has to be ligatured **in its continuity** at the injured ... which does not completely divide it, it must be exposed by ... dissection as the state of the parts will admit; the wound being ... necessary, in such a direction as to do the least possible injury to ... structures.

... any reason a Surgeon determine to apply a ligature at a distance ... the seat of the disease or injury, he selects that part of the vessel which ... adapted to the operation, and guided by his anatomical knowledge ... it on the chosen spot. The particular operations by which each of the ... arteries may be exposed and tied will be described in the chapter on the ... of Special Aneurisms; but the general principles which guide the ... in the application of a ligature to a large artery in its continuity will ... given here.

Whenever it is possible, the ligature should be applied at some distance ... any branch, in order that the formation of the internal coagulum may ... interfered with, either by the stream of blood leaving the main trunk ... on the proximal side of the ligature, or by that entering it by means ... the collateral circulation on the distal side. When this is impossible, it is ... ure on the proximal side of the branch, so that a clot ... and protect the injured part of the vessel from the direct ... of blood from the heart. In some cases, especially if

the anastomosing vessels are very abundant, it would be safer to ligature the branch also close to the main trunk.

Other things being equal, that part of the artery is to be chosen which is most superficial, and in relation with the fewest important structures. Thus the point selected in the carotid is above the omo-hyoid, and the superficial femoral is always, when possible, tied in preference to the popliteal.

Having determined the point to which the ligature is to be applied, the operator first makes an incision through the skin and fat to the deep fascia; he then, by careful dissection, exposes the sheath of the vessel, and finally opens the sheath and passes the aneurism needle between it and the external coat.

The first incision is usually made in the course of the vessel; for in most parts of the body the chief nerves, veins, and muscles run in the same line as the main artery. When, however, an incision in the line of the artery would injure important parts, the Surgeon must make an oblique or transverse wound, the direction being determined by the anatomical relations of the part. Thus in ligature of the brachial at the bend of the elbow, the incision is made across the line of the artery, in order to avoid the median basilic vein; and in ligature of the external iliac it is made nearly parallel to Poupart's ligament to facilitate the retraction of the peritoneum in exposing the artery. In making the incision, the Surgeon is guided by some fixed line known as the "*directing or guiding line*." In some cases this corresponds with the anatomical line of the artery, as in the operation for ligature of the anterior tibial; in others it is distinct from this, having reference rather to the structures which have to be turned on one side to expose the vessel. Thus in the operation for ligature of the carotid artery, the directing line for the first incision is the inner edge of the sterno-mastoid, while the line of the artery is from midway between the angle of the jaw and the mastoid process to the sterno-clavicular articulation. Both the anatomical line of the artery and the surgical directing line should be carefully studied and kept in mind.

In making the first incision, the skin should be put on the stretch by the fingers of the left hand. The length of the incision will necessarily vary with the depth of the artery and with the amount of superficial fat; but it must always be sufficient to give the operator a clear view of what he is doing in the deeper dissection. If the artery be superficial, or if there be parts of importance in its vicinity, the first incision should not penetrate deeper than the skin. But if the vessel be deeply seated and no parts of importance intervene, it may be carried at once through the subcutaneous areolar tissue, until the fascia is exposed. This must then be pinched up with the forceps, and opened by the edge of the scalpel laid horizontally (Fig. 132, p. 433). Through this opening a grooved director may then be passed, and the fascia incised upon it without risk to subjacent parts; or the fascia may be carefully divided by the method described on p. 44, Fig. 7.

If the vessel be superficial, its sheath will come into view as soon as the deep fascia is divided, and the operator proceeds at once to clean the artery and to pass the ligature; but if it be more deeply seated, the dissection must be continued till the vessel is exposed. In carrying out the deeper dissection, the Surgeon is still guided by definite anatomical points, each of which must be made out in order, and clearly recognised. Malgaigne gave these the name of the "*rallying-points*" of the operation, and laid down the following excellent rule: "The Surgeon should not at once set himself to look for the artery,

instrument; thus, it occasionally seized other tissues with the artery, and, occasionally, an accidental puncture having been made by it behind the part of the vessel to which the ligature was applied, ulceration and subsequent fatal hæmorrhage ensued, as I have seen in one case. The most convenient instrument for the purpose of drawing forward the artery, and one to which no objection whatever applies, is Liston's "bull-dog" forceps. These have been conveniently modified by having the blades expanded just above the points (Fig 130), so that the ligature can be slipped over their end on to an artery that is deeply seated, as between bones or close to the interosseous membrane of the leg—a situation in which it is sometimes troublesome to tie a vessel by any other means.

In applying the ligature, care must be taken that it be put well over the cut end of the artery, that it clear the points of the forceps, and that it be tied tightly in a reef-knot, which will not slip (Fig. 131). As the knot is tightened, the tips of the forefingers should be in close contact with the points of the forceps, and be pressed slightly downwards on the artery, otherwise the vessel may be dragged forwards out of its bed, or the forceps pulled off it. In

Fig. 130.—Liston's "Bull-dog" Forceps, modified.

Fig. 131.—The Ligature, or reef-knot.

some cases the bleeding point may be so situated, that the ligature is most conveniently passed round it by means of an ordinary curved needle.

2. When the artery has to be ligatured **in its continuity** at the injured spot for a wound which does not completely divide it, it must be exposed by as careful a dissection as the state of the parts will admit; the wound being enlarged, if necessary, in such a direction as to do the least possible injury to surrounding structures.

If for any reason a Surgeon determine to apply a ligature at a distance from the seat of the disease or injury, he selects that part of the vessel which is best adapted to the operation, and guided by his anatomical knowledge exposes it in the chosen spot. The particular operations by which each of the main arteries may be exposed and tied will be described in the chapter on the treatment of Special Aneurisms; but the general principles which guide the Surgeon in the application of a ligature to a large artery in its continuity will be given here.

Whenever it is possible, the ligature should be applied at some distance from any branch, in order that the formation of the internal coagulum may not be interfered with, either by the stream of blood leaving the main trunk immediately on the proximal side of the ligature, or by that entering it by means of the collateral circulation on the distal side. When this is impossible, it is safer to apply the ligature on the proximal side of the branch, so that a clot may be formed above it and protect the injured part of the vessel from the direct impulse of the stream of blood from the heart. In some cases, especially if

the anastomosing vessels are very abundant, it would be safer to ligature the branch also close to the main trunk.

Other things being equal, that part of the artery is to be chosen which is most superficial, and in relation with the fewest important structures. Thus the point selected in the carotid is above the omo-hyoid, and the superficial femoral is always, when possible, tied in preference to the popliteal.

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In making the first incision, the skin should be put on the stretch by the fingers of the left hand. The length of the incision will necessarily vary with the depth of the artery and with the amount of superficial fat; but it must always be sufficient to give the operator a clear view of what he is doing in the deeper dissection. If the artery be superficial, or if there be parts of importance in its vicinity, the first incision should not penetrate deeper than the skin. But if the vessel be deeply seated and no parts of importance intervene, it may be carried at once through the subcutaneous areolar tissue, until the fascia is exposed. This must then be pinched up with the forceps, and opened by the edge of the scalpel laid horizontally (Fig. 132, p. 433). Through this opening a grooved director may then be passed, and the fascia incised upon it, without risk to subjacent parts; or the fascia may be carefully divided by the method described on p. 44, Fig. 7.

If the vessel be superficial, its sheath will come into view as soon as the deep fascia is divided, and the operator proceeds at once to clean the artery and to pass the ligature; but if it be more deeply seated, the dissection must be continued till the vessel is exposed. In carrying out the deeper dissection, the Surgeon is still guided by definite anatomical points, each of which must be made out in order, and clearly recognised. Malgaigne gave these the name of the "*rallying-points*" of the operation, and laid down the following excellent rule: "The Surgeon should not at once set himself to look for the artery,

but should seek solely the first rallying-point; then the second; then the third, if there is one; and so on, till he reaches the vessel." Thus in the operation of ligature of the carotid, the first rallying-point is the inner edge of the sterno-mastoid, and until that is made clear, nothing else should occupy the operator's mind; the second point is the upper border of the anterior belly of the omo-hyoid, and it is not till this is found and drawn downwards that the artery itself need be thought of. During the deeper dissection the wound must be held open with blunt hooks or copper spatulæ, and this duty should if possible be entrusted to a single assistant. If two undertake it, one is sure to pull more strongly than the other, and thus disturb the relation of the superficial wound to the deeper parts.

Having reached the sheath, the next step of the operation consists in exposing the artery, and is one of great delicacy. The object of the operator is to open the sheath in such a way that the needle can be passed between it and the external coat, and at the same time to separate the artery from its sheath for as short a distance as possible. Separation of an artery from its sheath cuts off the blood-supply of its coats, as this is derived from the vasa vasorum which ramify in the sheath; if, therefore, the artery be separated extensively, the isolated part will slough. At the same time, it is very important that the artery be really separated cleanly from the sheath, as if this is done a smaller amount of tissue is included in the ligature, and the division of the inner and middle coats is more perfectly effected. Perfect cleaning of the artery, moreover, greatly facilitates the passage of the needle. If we cut an artery through, it retracts within its sheath, leaving that attached to the surrounding parts. This clearly shows that the sheath is more adherent to the surrounding parts than to the external coat, and that the loosest tissue, through which the needle will pass most readily, is that between the sheath and the outer coat. In fact, if the artery be properly cleaned, it is very unlikely that any accident will happen in passing the needle.

It must not be forgotten that some of the larger arteries are enclosed in a sheath derived from the fascia of the part, and it is important not to confound this with the true sheath. Thus, the carotid artery is enclosed in the sheath of cervical fascia common to it, the jugular vein, and the pneumogastric nerve, and in this case the operator will have to open the true sheath of the artery after having exposed it by opening the common sheath. The sheath of an artery may usually be recognised by the small vessels that can be seen ramifying in it, while the external coat is almost white, like the conjunctiva and the sclerotic of the eye respectively. Syme's rule in cleaning an artery, "to dissect down till the 'white coat of the vessel' comes into view," is founded upon this fact.

The sheath is opened by pinching it up with the forceps and applying the knife horizontally (Fig. 132). The point should never be used, nor the blade turned downwards against the artery, as an incautious movement or the mere pulsation of the vessel might cause it to be wounded. If the white coat of the artery does not come into view at once, it will be because the sheath is not completely divided, and the operator must then pinch it up again in exactly the same place, and again cut the areolar tissue seized in the forceps. The appearance of the white external coat, and the exceedingly loose areolar tissue which comes into view, show him when he has completely opened the sheath. He then catches hold of the edge of the opening he has made, and, putting it

outer one. The divided coats are separated for a short distance from the external coat and turned upwards and downwards into the lumen of the vessel.

The first change that takes place after the application of the ligature is the **Formation of the Internal Coagulum**. For the first few hours there is little if any appearance of this; but, within about twenty-four or thirty-six hours after the application of the ligature, a coagulum will usually be found extending some distance from the ligature and adherent by its base to the injured part of the vessel. The part in immediate contact with the divided inner and middle coats will by this time be found to be of a yellowish or buff colour, owing to its being infiltrated or replaced by the inflammatory exudation which has been poured out in the bottom of the *cul-de-sac* formed by the turn-

Fig. 136.—Immediate effects of the Application of a Ligature.

Fig. 137.—Femoral Artery, fifty-six hours after Amputation.

ing inwards of the divided coats. About the third day the clot (Figs. 137 and 138) will be found to be conical in form, firmer in structure, and more adherent to the inner coat of the artery, and by this time it extends most frequently as far as the nearest branch given off from the vessel above the ligature (Fig. 139). Its base is more distinctly decolorised, the remainder being of a dark purple or maroon colour. Its apex lies loose and floating in the artery.

The further changes that occur within the artery are the same as those already described as taking place in the permanent closure of a divided vessel (p. 415).

In some cases, there is an imperfect formation of the internal coagulum, or even a total absence of it should a branch arise immediately above the ligature. In other cases, the insufficient formation of the coagulum is apparently due to the constitutional condition of the patient. Sometimes the clot seems to undergo a kind of disintegration or liquefaction after it has been formed (Fig. 140). This I have seen happen in a case of ligature of the carotid artery, in which death occurred from visceral disease ten weeks after the operation; and in the femoral, in cases of pyæmia.

When an artery is ligatured in its continuity the coagulum formed in the distal *cul-de-sac* is seldom so abundant as that on the proximal side of the ligature. In other respects the internal changes that occur are identical on the two sides of the ligature.

but should seek solely the first rallying-point; then the second; then the third, if there is one; and so on, till he reaches the vessel." Thus in the operation of ligature of the carotid, the first rallying-point is the inner edge of the sterno-mastoid, and until that is made clear, nothing else should occupy the operator's mind; the second point is the upper border of the anterior belly of the omo-hyoid, and it is not till this is found and drawn downwards that the artery itself need be thought of. During the deeper dissection the wound must be held open with blunt hooks or copper spatulæ, and this duty should if possible be entrusted to a single assistant. If two undertake it, one is sure to pull more strongly than the other, and thus disturb the relation of the superficial wound to the deeper parts.

Having reached the sheath, the next step of the operation consists in exposing the artery, and is one of great delicacy. The object of the operator is to open the sheath in such a way that the needle can be passed between it and the external coat, and at the same time to separate the artery from its sheath for as short a distance as possible. Separation of an artery from its sheath cuts off the blood-supply of its coats, as this is derived from the vasa vasorum which ramify in the sheath; if, therefore, the artery be separated extensively, the isolated part will slough. At the same time, it is very important that the artery be really separated cleanly from the sheath, as if this is done a smaller amount of tissue is included in the ligature, and the division of the inner and middle coats is more perfectly effected. Perfect cleaning of the artery, moreover, greatly facilitates the passage of the needle. If we cut an artery through, it retracts within its sheath, leaving that attached to the surrounding parts. This clearly shows that the sheath is more adherent to the surrounding parts than to the external coat, and that the loosest tissue, through which the needle will pass most readily, is that between the sheath and the outer coat. In fact, if the artery be properly cleaned, it is very unlikely that any accident will happen in passing the needle.

It must not be forgotten that some of the larger arteries are enclosed in a sheath derived from the fascia of the part, and it is important not to confound this with the true sheath. Thus, the carotid artery is enclosed in the sheath of cervical fascia common to it, the jugular vein, and the pneumogastric nerve, and in this case the operator will have to open the true sheath of the artery after having exposed it by opening the common sheath. The sheath of an artery may usually be recognised by the small vessels that can be seen ramifying in it, while the external coat is almost white, like the conjunctiva and the sclerotic of the eye respectively. Syme's rule in cleaning an artery, "to dissect down till the 'white coat of the vessel' comes into view," is founded upon this fact.

The sheath is opened by pinching it up with the forceps and applying the knife horizontally (Fig. 132). The point should never be used, nor the blade turned downwards against the artery, as an incautious movement or the mere pulsation of the vessel might cause it to be wounded. If the white coat of the artery does not come into view at once, it will be because the sheath is not completely divided, and the operator must then pinch it up again in exactly the same place, and again cut the areolar tissue seized in the forceps. The appearance of the white external coat, and the exceedingly loose areolar tissue which comes into view, show him when he has completely opened the sheath. He then catches hold of the edge of the opening he has made, and, putting it

wounds have diminished the frequency of secondary hæmorrhage in the same proportion as they have diminished pyæmia and other unhealthy processes.

Should the ligature be composed of an irritating material which has to cut its way through the ligatured vessel by ulceration, a localised inflammation with suppuration is kept up in the immediate neighbourhood of the injured part of the artery. As a rule this process is closely limited to the immediate neighbourhood of the ligature ; and, by the time the noose ulcerates through the external coat, repair is sufficiently advanced within the vessel to render it capable of withstanding the force of the blood-stream—the firm adhesion of the clot to the inner coat serving under these circumstances the important purpose of breaking the direct impulse of the wave of blood upon the new tissue closing the vessel. There are two sources of danger in connection with the coming away of the ligature : either the sloughing may be too extensive, or the ulceration through the artery may take place before the reparative material within is sufficiently firm. Too extensive sloughing may arise when the artery is tied in its continuity, from the vessel having been separated from its sheath to too great an extent during the dissection required to expose it, and its nutrient vessels consequently being divided in great numbers, so as to deprive that portion of the coats of the vessel of its vascular supply ; hence the danger of passing a spatula, director, or the handle of a scalpel under the artery, and also of applying several ligatures or a single wide one. When the artery has been divided, sloughing is most commonly the result of septic processes going on in the wound, especially if the artery have been cut long, so that its free end is bathed in the decomposing discharges. Premature ulceration of the vessel may occur from the use of too thick a ligature, which, by causing greater irritation, hastens the process of separation ; from excessive degeneration or inflammatory softening of the artery at the point ligatured ; or from unhealthy processes occurring in the wound, especially the pressure of pent-up decomposing discharges. As soon as the ligature has ulcerated through that portion of the artery which is included in its noose, it becomes loosened and separates ; frequently being thrown off with the discharges, or becoming detached on the slightest traction. The *period of the separation of the ligature* depends upon the size of the artery and the thickness of its coats and of the ligature itself. From the radial or ulnar arteries, it is usually detached by the eighth day ; from the femoral, iliac, or subclavian, about the sixteenth or twentieth day. In some cases the ligature may remain attached for a much longer period, owing to the inclusion within its noose of a bit of fascia, nerve, or muscular substance. In order to hasten the separation in these cases, moderate traction and occasional twisting of the ligature used to be practised.

The Ligature.—The best material to use for tying an artery has been the subject of much experimental injury and abundant discussion, and can hardly yet be said to be finally determined. Ligatures may be divided into two chief classes : first, those intended to cut through the artery by a gradual process of ulceration, and then to be removed from the wound ; and secondly, those intended to become enclosed in the wound during the process of healing, and either to remain permanently encapsuled or to be absorbed.

1. Until about twenty years ago, when absorbable ligatures were reintro-

duced into practice in connection with the antiseptic treatment of wounds, the vast majority of Surgeons made *use of ligatures which were removed from the wound after having cut through the artery by a process of ulceration.* The material commonly employed with this object was either "dentist's silk" or compressed whipcord well waxed. The ligature was waxed for three reasons: first, to make it more easy to tie when the operator's hands were slippery with blood; secondly, to prevent the danger of the knot slipping after it had been tied; and thirdly, to render it as far as possible non-absorbent, and thus to prevent its taking up septic matter, and becoming needlessly irritating. In the absence of antiseptic precautions, however, this last object was but imperfectly attained. The ligature always became impregnated with the products of putrefaction, and thus acting like a seton produced a suppurating track in its course. Inflammation and suppuration were thus kept up until the ligature separated and the source of irritation was removed. Thus no true repair could take place outside the ligatured vessel till after the removal of the ligature. In the vast majority of cases, however, the processes of repair going on inside the vessel were sufficient to close it safely; and thus hæmorrhage on the separation of the ligature was of comparatively rare occurrence. As has already been stated, the period at which the process of ulceration through the external coat was completed varied with the size of the artery and the thickness of the ligature. Malgaigne pointed out that the size of the ligature also exercised a marked influence on the time at which it came away; the thicker the ligature the greater the irritation it excited, and the sooner was the process of ulceration through the vessel completed. The finest thread possible, provided it was of sufficient strength, was used, as thereby the danger of premature separation was to a great extent avoided, while at the same time the inner and middle coats were more cleanly divided. In some rare cases, as, for example, when the coats of the artery were softened by inflammation, a thicker ligature was used for fear of cutting through the external coat. If it were intended to remove the ligature, one end was cut short and the other brought out of the wound at the most convenient part. Both ends of the ligature on the main artery in an amputation were left, and knotted together as a distinguishing mark. After the first four days the ligatures on the smaller vessels were gently pulled to see if they were loose. The ligature on the main artery was not touched till after the tenth day in the arm, and the fourteenth in the lower limb.

Ligatures are scarcely ever applied in this way at the present time, but it may, of course, happen to the Surgeon to be placed in circumstances in which prepared absorbable ligatures may not be at his command.

2. *Ligatures which become enclosed in the wound during the process of healing, and remain permanently encapsuled or become absorbed.*

Wire Ligatures have been used with this intention in America. The idea originated with Physick and Levert of Alabama, who performed several experiments with threads of gold, silver, platinum, and lead. They found that with these the arteries of animals could be successfully tied, and that, the material of the ligature being unirritating, no evil from suppuration ensued. When the ends of the ligature were cut off close to the vessel, it was found that the small metallic noose became embedded in a cellular capsule. For some reason this means fell into disuse, until it was revived by Marion Sims. At his suggestion I tried it in several cases of amputation and other surgical

bouring tissues, it is at least as easy to ligature the vessel as to twist it efficiently.

2. With reference to the comparative freedom from secondary hæmorrhage, we have few data; but all those Surgeons who have extensively employed torsion agree in stating that it is very rarely followed by secondary hæmorrhage. The same may, however, be said with equal truth of the ligature as used at the present time.

3. The torsion of arteries was strongly advocated on the ground that, whilst quite as safe as the ligature, there would after its employment be less liability to inflammation and suppuration, as no foreign body was left in the wound. This argument was used especially by Amussat; Manec and others maintained that the twisted end, of a large artery at any rate, is in reality a foreign body. At the present day, when the treatment of wounds is so much better understood than it was in their time, these arguments are of but little practical importance. We know that a piece of dead tissue, the size of the twisted end of an artery, becomes speedily buried in the exudation that forms during the first twenty-four hours after the infliction of a wound, provided that the cavity is properly drained, and the surfaces brought accurately together and kept at rest; and that under these circumstances it is readily absorbed without causing inflammation or suppuration. In fact, it acts as an irritating foreign body only when it remains uncovered and undergoes decomposition. The same is true of the ligatures in common use at the present day. On the other hand, the old silk ligature, the ends of which were left hanging out of the wound, infallibly acted as an irritant, and excited suppuration in its track. Torsion, therefore, undoubtedly presents advantages over the old silk ligature, and is equally safe and no more likely to interfere with primary union than an absorbable ligature. The latter possesses, however, the advantage of much greater ease of application, and is therefore preferred by the majority of Surgeons.

8. FORCIPRESSURE is a mode of arresting hæmorrhage which has been recommended as of use in certain cases by Spencer Wells, Koeberlé, and Péan. It consists in seizing the end of the vessel in a pair of forceps having strong short blades somewhat deeply serrated, and long scissor handles provided with a catch (Fig. 128). The forceps can be closed with sufficient force to crush the end of the vessel between the blades. The form of forceps represented in the figure is that invented by Spencer Wells, which is certainly the most convenient and efficient. The use of these forceps as a temporary means of arresting hæmorrhage has already been alluded to. When used in this way it will frequently be found that, on relaxing their hold after a few minutes, no bleeding takes place. Under these circumstances, experience shows that the closure of the vessel is as safe as that effected by torsion. Should the Surgeon wish to make the arrest of bleeding still more certain, he may give the forceps a few turns while removing them, and thus apply torsion. Forcipressure is occasionally useful in deep wounds in which a ligature cannot be applied. In these cases, in order to make the closure of the vessel more certain, the forceps may be left in the wound for twelve or twenty-four hours and then carefully removed.

9. LIGATURE is the means to which Surgeons commonly have recourse for the arrest of hæmorrhage from wounded arteries.

The Ligature was undoubtedly employed to a considerable extent by the

supported by pebbles at a short distance above the bottom, to afford space for water that slowly subsides to accumulate in and keep it from coming into contact with the hanks of gut which are placed loosely in the upper part of the vessel. The process of preparation goes on best in a cool place, and should be continued *for two months at least;* and the gut goes on improving for an unlimited time if retained in the same oil."

Excellent results were obtained with the gut prepared in this way, but the length of time required before it was fit for use formed a serious objection to the process. Lister therefore undertook a series of experiments with various reagents in the hope of finding some equally efficient and more rapid method. Among the substances with which he experimented, chromic acid was found to give the best results; but if this is used alone or too strong, the gut becomes over-prepared and as unabsorbable as a wire ligature. The method of preparation finally adopted was the following: Dissolve one part of chromic acid in 4,000 parts of distilled water, and add to the solution 200 parts of pure carbolic acid or absolute phenol. Place in the solution a quantity of catgut equal in weight to the carbolic acid: the gut must not be in loose hanks, but wound round some solid body to prevent its untwisting while soaking. If too much gut be added, it will be under-prepared and soften in the wound; if too little, there is a danger of its becoming over-prepared and unabsorbable. At the end of forty-eight hours the preparation is complete, and the gut may be removed and dried. Another mode of preparing the gut is as follows: Take five parts by weight of catgut (wound as above on some solid body) and immerse for twelve hours in chromic acid 1 part and distilled water 100 parts; transfer after removing the excess of liquid with a cloth into 100 parts of sulphurous acid (B. P.); in twelve hours take it out and dry it. As soon as it is dry, it is to be placed in a 1 to 5 solution of carbolic acid in oil, and it is then fit for use; or it may be kept dry and put in a 1 in 20 watery solution for a quarter of an hour before it is used.

Max Schede of Hamburg has used catgut prepared with perchloride of mercury with perfectly satisfactory results. The catgut is wound on a glass reel and placed in a 1 per cent. solution of corrosive sublimate. The thinner sorts remain in six hours, the thicker twelve. The catgut is then removed and placed for twelve hours in absolute alcohol, when it is ready for use. It is kept till required in the alcohol.

The fate of a prepared catgut ligature in a wound has been the subject of much discussion. The examination of ligatures applied in animals, and of pieces of gut used as sutures and ligatures in the human subject, has, however, tolerably clearly proved that, provided all goes well, the following changes occur. Within a short time of its application the carbolic acid or other soluble antiseptic it contains diffuses out of it and the catgut then becomes a perfectly unirritating thread of fibrous tissue, and has no tendency to excite inflammation in its neighbourhood. It may, however, become irritating if, after losing its carbolic acid, it decomposes or becomes soaked in decomposing discharges. In this state it presents no advantage over an ordinary silk or hemp ligature; in fact it is less safe, as by its premature softening it may leave the external coat [illegible] before repair has sufficiently advanced internally. If pre[illegible]omposition by the antiseptic treatment, it becomes buried [illegible]e granulation-tissue developed in the process of repair of

und. In properly prepared catgut the absorption proceeds solely from rface, the ligature swelling and softening but little. If such a ligature mined when partially absorbed, it will be found that the surface has s smooth outline, being eaten out into hollows, which are filled with aving the appearance of leucocytes. Occasionally a few larger, many-ted cells are met with. In an imperfectly prepared ligature the cells seen penetrating deeply into the substance of the gut between the s of fibrous tissue. Fig. 141 represents the surface of a piece of car- catgut $\frac{1}{25}$-in. in thickness, used as a deep stitch in a wound treated tically, and healed by the first intention. It was removed at the f six days, and was still tough and strong, being only superficially ed, about one-fifteenth of its thickness having disappeared. The gut epared by the old process, without chromic acid, and had been in carbolic about three years. A portion of the same hank had been successfully ligature the femoral artery in a case of popliteal aneurism.

lly, as has been shown by Lister, the ligature completely disappears, a ing of new fibrous tissue being ped round the vessel in its place. the artery is not cut through, ntinuity of the external coat ing uninterrupted. The inner iddle coats are as a rule cut h in the application of the liga- but should it be thought advis- ot to do this, as in the case of f the larger arteries, it can be d by using the thickest obtain- ut, and employing less force in lication.

Fig. 141.—Absorption of catgut ligature six days in an aseptic wound. Surface of catgut is splitting up. Leucocytes cover it and wander into the fissures. *l.* leucocytes ; *c.* catgut fibres.

use of the catgut ligature has wever, been limited to wounds antiseptically, and good results have been obtained in cases treated by nethods. In these cases the fate of the ligature is less certain. If it s buried in the coagulable exudation which unites the surfaces of a well- d and perfectly rested wound in the first few hours, it is protected from position, and then follows the course above described. If it should bathed in septic discharges it softens rapidly, and the knot is usually off like a small slough, or the ligature may break up and disappear her.

changes that occur within the artery after the application of a catgut do not differ, so far as is known, from those following any other mode sting arterial hæmorrhage.

use of the catgut ligature has not been altogether unattended with ts. These have been due in most cases to *premature softening* of the to *slipping of the knot.* The premature softening is due to imperfect ation. The older method of preparing carbolised catgut occupied at wo months, and even then it was occasionally under-prepared. This t has been less frequent since the employment of the new form of prepared by means of chromic acid. The slipping of the knot is nes due to the gut being too rigid to tie closely ; such gut should never

be used. Well-prepared gut will tie as closely as silk of the same thickness. When applied to an artery in its continuity, the catgut ligature has in some cases failed to obliterate the vessel. Thus, in a case under the care of Christopher Heath, at University College Hospital, the femoral became pervious shortly after the operation, necessitating the application of a second ligature at a lower point. In a case recorded by T. Smith, of St. Bartholomew's Hospital, not only did the ligature fail to obliterate the artery, but a traumatic aneurism formed at the point at which it had been applied. McCarthy has also recorded a case in which the artery became pervious shortly after the operation. In these cases the ligature failed to accomplish the purpose for which it was applied. It is most probable that in all it was due to premature softening of the gut. Treves also has recorded a case in which after 108 days the carotid artery was found to be patent but narrowed at the seat of ligature by a kind of perforated diaphragm. In a case at University College Hospital, in which the right carotid was tied below the omo-hyoid for an aneurism opposite the larynx, the vessel, when the man died of an aortic aneurism one year after, was found to be obliterated from the aneurism to the innominate. Its coats were continuous, the seat of ligature being recognisable only by some cicatricial tissue adherent to the external coat. It seems possible, therefore, that as the continuity of the external coat is not destroyed, restoration of the lumen of the vessel may take place occasionally even after occlusion lasting a considerable time. In the vast majority of cases, however, in which the catgut ligature has been employed, the vessel has been permanently and safely obliterated.

Carbolised Silk.—The slight degree of uncertainty that has attended the use of catgut, the occasional premature disappearance of the ligature and restoration of the lumen of the vessel, have led some Surgeons to employ fine silk, that known as "Chinese twist" being the best. Silk being an animal substance, and from its softness being unlikely to irritate mechanically, there seems no reason why, if it can be prevented from becoming impregnated with the irritating products of putrefaction, it should not lie harmlessly amongst the tissues, and finally become absorbed or encapsuled. That such has been the case has been abundantly proved by the experience derived from those cases of ovariotomy in which the pedicle has been secured with silk and returned into the cavity of the abdomen. In order that silk may be used with safety and certainty, it must in the first place be rendered aseptic. This is most efficiently done by boiling it for some time in water, and afterwards placing it for twenty-four hours in a 1 in 20 solution of carbolic acid, or in a 1 in 500 solution of corrosive sublimate. It must on no account be waxed, as this makes it incapable of being absorbed. A silk ligature thus prepared will in the great majority of cases give rise to no irritation or suppuration in its neighbourhood. If, however, it should from any cause become exposed to decomposing matter, it will absorb the products of putrefaction, and will then be cast off and discharged from the wound by suppuration.

The fate of a silk ligature when left amongst the living tissues has been experimentally investigated by Lister, Spiegelberg and Waldeyer, Tillmanns, nd others. Lister found an aseptic silk ligature applied to the carotid of a unchanged at the end of six weeks and embedded in firm fibrous tissue. e in which he applied a similar ligature to the external iliac artery man subject, when he had the opportunity of examining the parts

one year after, he found the greater part of the ligature absorbed, but a small abscess had formed around the knot. Clutton has recorded a case in which the noose of the ligature was discharged from an abscess six weeks after ligature of the external iliac. Boyd had the opportunity of examining a similar ligature applied to the carotid thirty-five days before death, the wound having healed by first intention. The silk was found perfectly unchanged, surrounded by a mass of small round cells with some giant-cells. In another case, recorded by Horsley, a silk ligature was found unchanged after seven weeks. The connective tissue formed a strong fibrous capsule round it, but presented here and there signs of chronic inflammation. The results of experiments on animals by Spiegelberg and Waldeyer, and Tillmanns, agree in every respect with those just mentioned.

It appears, therefore, that a silk ligature may, with proper antiseptic precautions, be safely applied and left in the wound, with a good prospect of its being encapsuled in fibrous tissue and ultimately absorbed.

Tendon Ligatures.—Long tendons dried and afterwards carbolised have also been used as ligatures. Girdlestone of Melbourne has successfully made use of the long tendons from the tail of the kangaroo. These form excellent and most reliable ligatures, and their use has been especially advocated by Dent and Delépine; they are uniform in structure, and undergo absorption very slowly.

Ligature of Arteries without Dividing the Inner and Middle Coats.—In the application of the catgut or silk ligature, it is the object of the Surgeon, as before stated, to tie sufficiently tightly to cut through the inner and middle coats of the artery, and by the compression of the outer coat to turn their divided edges upwards and downwards into the lumen of the vessel. Alexander Monro, B. Bell, Scarpa, and many other Surgeons at the end of the last century and the beginning of this, advocated a more gentle application of the ligature, so as merely to compress the coats to the degree necessary to obstruct the flow of blood, under the impression that the patient's safety was increased by doing less damage to the artery. The observations of Jones, and the experience of all Surgeons, however, proved almost beyond a doubt that if the ligature was to cut through the artery and come away, the safety of the patient depended chiefly on the employment of the finest possible ligatures, tightly tied, so as to cut the inner and middle coats cleanly and completely, and turn them up into the lumen of the vessel in such a way as to plug it almost as thoroughly as in torsion. Broad ligatures loosely tied excited much suppuration round the artery, cut through quickly, and were frequently followed by secondary hæmorrhage. The idea, however, that a vessel can be safely tied without injuring its coats was revived in connection with the absorbable ligatures now in use. Lister at first suggested that the catgut ligature might be applied in this way, but experience seemed to show that its early absorption rendered the obliteration of the vessel uncertain unless the inner and middle coats were cut. R. Barwell has, however, introduced a variety of ligature prepared from the middle coat of the aorta of the ox, which he has successfully applied in a considerable number of cases without injuring the coats of the artery. The **Ox-aorta Ligature** is prepared by separating the outer coat and cutting the middle coat spirally into a long ribbon. This is stretched, by hanging to it a weight of from one to three pounds, according to the breadth of the ligature, and allowed to dry. Ten minutes before being

used it must be soaked in a 1 in 20 solution of carbolic acid in v
breadth of the ligature makes it impossible to divide the inner
coats of the artery while tying it, and it seems to be more slowly ab
carbolised catgut. In 1881 Barwell reported fourteen cases in
ligature had been successfully applied to large arteries. In eve
obliteration of the vessel was accomplished and nothing was
ligature after the operation.

The subject has been brought forward again by C. A. B
W. Edmunds, who, by a series of carefully conducted experime
that in horses and sheep large vessels can be successfully oblitera
division of any of their coats by the application of a small round ch
or tendon ligature tied so as merely to arrest the flow of blood. Su
will resist absorption for at least three weeks (a longer period t
carbolised catgut), and by that time the artery, in all their exper
safely obliterated. The mere pressure of the ligature is sufficie
proliferation of the endothelium, and union of the surfaces
gether, thus occluding the vessel. They therefore maintain that i
of ligature of an artery in its continuity, it is neither necessary n
to rupture the coats. The probability is that in all arteries of
the superficial femoral, and below it, it matters little, as far as s
cerned, whether the coats are divided or not, provided the wound
aseptic course and unites by first intention, and probably permane
will be more certain if the inner and middle coat are cut. In lar
however, secondary hæmorrhage has occurred with great freq
ligature with division of the coats, and in some, such as the first
subclavian, the innominate, and the aorta, with such constancy t
hope of success seems to lie in not injuring the arterial wall.

Temporary Ligatures.—With the view of removing the v
veniences that resulted from the presence of the ligatures in th
especially with the object of promoting union by the first in
Surgeons attempted the use of temporary ligatures.

This subject has now in a great measure become matter of
study of which the writings of Jones, Travers, Velpeau, and
referred to. It may, however, be stated, that the general result
ments made and the experience gained on this subject is as fo

Jones found that, on cutting through the internal and mi
carotid artery of a horse at three or four different points, wi
tures, and then *immediately* removing them, an "effusion of
by which the artery was plugged up." These observations w
by other experimenters, such as Hodgson, Travers, and
Travers found that, if the ligature was left in for several
one hour, and then removed, obliteration of the artery en
plied a ligature to the femoral artery for popliteal aneurism
it after 24 hours, found the artery closed; and Travers li
artery of a man, and, on removing the ligature at th
obtained an equally successful result. Their example wa
and Paletta. Notwithstanding these favourable result
method in the hands of Astley Cooper, Hutchinson,
himself, and the observation of Vacca that, if the ligatur
long enough to cause its obliteration, the section of the v

or later, caused the use of the temporary ligature to be discontinued in surgical practice even by those who had at one time most strongly advocated it.

10. ACUPRESSURE.—By Acupressure is meant the occlusion of an artery by the pressure of a needle in such a way as to arrest the circulation through it or the hæmorrhage from it. This method of treatment was introduced into surgical practice by the late Sir James Simpson as a substitute for the ligature. Acupressure may be applied in several different ways; but there are four principal methods.

The *first method* is explained by Figs. 142 and 143. The needle is passed

Fig. 142.—Acupressure. First Method. Raw Surface.

Fig. 143.—Acupressure. First Method. Cutaneous Surface.

through the cutaneous surface of the flap until its point projects on the raw surface, a little to one side of and above the orifice of the bleeding artery. The latter is then bridged over and compressed by the needle, which re-enters the surface of the wound on the other side of the vessel, and again passes outwards through the skin.

The degree of pressure required effectually to close an artery is certainly much less than Surgeons generally imagine; and in the above proceeding it can be regulated by the acuteness of the angle at which the needle is introduced and again passed out—the cutaneous and other structures of the flap serving as the resisting medium against which the needle compresses the arterial tube.

The *second method* of acupressure consists in taking a short sewing needle

Fig. 144.—Acupressure. Second Method.

Fig. 145.—Acupressure. Third Method.

with a piece of twisted iron wire attached, for the purpose of withdrawing it when necessary. This is dipped down into the soft tissues on one side of the artery; then bridged over the vessel; then dipped down again into the soft structures on the other side of the vessel (Fig. 144). In doing this care must be taken to press the end of the needle down upon the bleeding trunk or tube of the artery with sufficient force.

The *third method* consists in compressing the artery between the needle passed below it and a loop of fine iron wire passed over it. The needle is

passed as in the last cases, but on the opposite side of the artery. The loop of iron wire is thrown over the point of the needle; it is then passed across the artery, drawn tight so as to compress the vessel, and secured by a half twist round the eye end of the needle (Fig. 145). In order to remove this apparatus, all the Surgeon has to do is to pull the twisted wire with which the needle is threaded; this, in withdrawing the needle, liberates the loop, which may then easily be removed.

The *fourth method* consists in dipping the needle into the tissues close to the artery, then making a turn with the point, and pushing this into the soft parts beyond, so as to fix it there, and thus to compress the artery (Fig. 146).

Fig. 146.—Acupressure. Fourth Method.

The *Condition of the Artery* after having been subjected to acupressure has been determined both by experiments on animals and by observations on the human subject. It has thus been ascertained that the pressure of the needle is never sufficient to divide the internal and middle coats. Occlusion of the artery is effected first by the formation of an adherent clot within the vessel between the point compressed and the nearest collateral branch. The orifice is at the same time sealed by the plastic exudation uniting the surfaces of the wound. It has been shown that in arteries tied without injury to their coats, proliferation of the endothelium takes place in the neighbourhood of the ligature, the new cells growing into the adherent clot, and no doubt the same process occurs after closure of a vessel by acupressure.

The time during which the needle should be left in will vary, according to the size of the artery, from thirty to sixty hours. The needle must not be left in too long, lest irritation be set up and ulceration induced along its track.

At the time that acupressure was introduced hæmorrhage was almost exclusively arrested by silk or hemp ligatures which necessarily formed a barrier to complete union by the first intention. By the early removal of the acupressure pins and wires it was hoped that the wound, being freed from all foreign bodies, would heal without suppuration, and in many cases this result was obtained; but the introduction of the antiseptic treatment and the use of absorbable ligatures brought about the desired result in a much simpler and more certain manner, and acupressure never came into general use. Sufficient experience was obtained, however, to show that even large vessels may be safely obliterated by these means, and circumstances may occasionally arise in which a knowledge of them will be of use to the Surgeon.

COLLATERAL CIRCULATION.—When the main artery of a limb has been ligatured, or in any other way occluded, it is only the direct flow of blood that is interrupted; the indirect supply which is conveyed into the part, by the free communication between the anastomosing vessels of the different portions of the arterial system, is sufficient to preserve its vitality and to prevent ...ccurrence of gangrene. So free are the inosculations between different ...s of the arterial system, that, after the largest arteries in the body, such ... subclavian, the iliac, and even the abdominal aorta, have been ligatured, ...ent blood to support life is at once conveyed into the parts supplied by ... This **collateral circulation** is most active in early life, when the

vessels are pliant and elastic, readily accommodating themselves to the increased quantity of blood that they are required to convey. As age advances, the vascular system becomes less elastic, and there is a greater difficulty in the establishment of the collateral circulation. The anastomosing vessels which serve this purpose are invariably furnished by arteries contiguous to that which is ligatured, and come off from the same side of the body. Thus, for instance, after ligature of the superficial femoral, it is by the profunda artery that the supply of blood is carried to the lower extremity. Thus also, when the common carotid is ligatured, the circulation to the parts it supplies is not maintained through the medium of the opposite carotid, although the inosculations between the ultimate branches of the two vessels are so free upon the throat, and the face, and within the cranium; but it is by means of the inferior thyroid and vertebral arteries (branches of the subclavian on the same side), which become greatly enlarged, that the supply of blood is kept up to the parts on the outside as well as in the inside of the cranium.

The supply of blood that is sent to a limb, after deligation of the main trunk, is at first but small in quantity; being merely sufficient for the maintenance of its vitality, but not enough for the continuance of the usual function of the part. Hence, although the life of a limb may be preserved after the ligature of its artery, it becomes cold, and the patient is often unable to move it for some time, the muscles appearing to be completely paralysed; in a few hours, however, the supply of blood increases, until it reaches its usual standard, when the normal vigour of the part returns. By the end of twenty-four hours the limb will be found to be redder than natural, and the temperature often rises one or two degrees beyond that of the opposite limb, whilst a great sensation of heat is experienced in it by the patient. This period of increased heat may last a week or more.

The re-establishment of the blood-supply to the limb after obliteration of the main trunk is accomplished chiefly by changes taking place in the *Anastomosing Arteries.* Almost immediately after the ligature is tightened they become dilated to their extreme capacity. This is due in a very slight degree to the increased tension caused by the sudden obliteration of the main trunk, for that is equally felt throughout the whole body, except the part supplied by the ligatured artery. It is chiefly the result of relaxation of the muscular coat. This relaxation is probably a reflex phenomenon consequent upon the want of blood in the parts beyond the point of obliteration of the artery. We have already seen that a similar dilatation of the vessels occurs when a limb has been rendered bloodless for a short time by an Esmarch's bandage. The dilatation is not limited to the anastomosing vessels which are directly concerned in carrying the blood from above to below the ligature, but affects the whole arterial system of the limb. It is this that causes the increased redness a few hours after the ligature has been applied. The resistance to the flow of blood is necessarily reduced to the smallest possible degree by this general vascular dilatation, and this to some extent compensates for the increased resistance which necessarily results from the blood having to be driven through a number of small anastomosing arteries, instead of through a single main trunk. The preliminary dilatation is followed by a permanent enlargement of the anastomosing arteries, which increase both in diameter and in length, and thus assume a tortuous or waved form.

Thus in a case of spontaneous obliteration of the first part of the axillary

artery, met with in the dissecting-room of University College, a tortuous vessel, about the size of a crow-quill, and measuring, when straightened out, nine inches in length, was found passing from the internal mammary in the third intercostal space to the external mammary branch of the axillary. Occasionally a number of such arteries may form an interlacement. The anastomosing arteries that carry on the circulation are, as a rule, easily dissected out in a well-injected subject in the dissecting-room, and at one time it was supposed that it was not safe to tie a large artery except in those situations in which such easily demonstrable anastomoses exist. Thus, for instance, after the ligature of the common carotid, the supply of blood is ultimately conveyed by the inosculations between the superior and inferior thyroid arteries and by the vertebral. When the subclavian is tied the circu-

Fig. 147.—Anastomosing Circulation in Sartorius and Pectineus of Dog, three months after Ligature of Femoral. (After Porta.)

Fig. 148.—Direct Anastomosing Vessels of Right Carotid of Goat, five months after Ligature. (After Porta.)

Fig. 149.—Change in the Trunk after Ligature; with Anastomosing Vessel.

lation of the upper extremity is carried on by the anastomosis of the posterior scapular and suprascapular from the thyroid axis, with the acromio-thoracic and subscapular of the axillary, of the branches of the internal mammary and intercostal arteries with the external mammary of the axillary, and of the superior intercostal of the subclavian with the superior thoracic of the axillary; and when the external iliac is tied, the blood is conveyed to the lower limb by the inosculations between the internal mammary and lumbar arteries and the epigastric and circumflex ilii, and by those between the obturator, gluteal, and sciatic arteries, and the circumflex branches of the profunda femoris.

It has, however, repeatedly been shown that the ordinary muscular and subcutaneous vessels of the part are amply sufficient to carry on the circulation, even when no anastomosing arteries can be demonstrated by dissection.

ial vessels ultimately destined to take the place of that which has rated enlarge, the general vascular dilatation of the limb subsides culation is practically restored to its normal condition. During ment of the vessels, much pain is often experienced, owing to the the dilated vessels upon neighbouring nerves.

inted out the curious circumstance that, occasionally when two g branches approach one another, they split, before inosculating, three ramusculi, which by uniting form a circle of anastomoses. s kind of collateral circulation, Maunoir, Porta, and Stilling have sels running directly between the extremities of the obliterated ing species of arterial shoots, springing from the stump of the 147).

s that take place in the Trunk.—As a rule it is completely above and below the point to which the ligature has been applied next important collateral branch (Figs. 148, 149). Beyond this, l side, it is pervious and receives the blood poured into it through t anastomosing channels. Porta and Stilling have shown that, , a small tortuous central canal uniting the two parts of the vessel till patent, may be developed down the centre of the fibrous cord the obliterated portion of the artery.

n which an absorbable ligature has been used and in which conse- external coat has not been divided, complete restoration of the e vessel seems to be an occasional occurrence (see p. 442).

teral circulation is occasionally not sufficiently free to preserve the he parts supplied by it; as a consequence of this, gangrene results, may become weak or atrophied. This condition may be met with e, from calcification and rigidity of the arterial system; or it may he result of an extensive transverse wound of the limb dividing e anastomosing vessels. Copious hæmorrhage by weakening the e heart may render it unable to overcome the increased resistance he collateral circulation through which the blood has to pass, and culation may be arrested and gangrene follow. It more rarely t we find too great freedom of the anastomoses, so as to lead to a e purposes for which the ligature has been applied, by the rapid blood into the distal side of the vessel, thus perhaps occasioning emorrhage.

S OF TREATMENT OF PRIMARY ARTERIAL HÆMORRHAGE.— les of treatment of wounded arteries are the same whether the pt ligature, torsion, or acupressure. Having invariably used myself, I have here spoken of tying only, but the reader must at the same principles apply to all other means of arresting orrhage.

rine of the treatment of primary hæmorrhage from wounded omprised in three great principles: 1. "*That no operation ought ed on a wounded artery unless it bleeds*" (Guthrie); 2. *To expose it be bleeding, at the wounded part, and to tie it there; and* 3. *To ure to both ends, if it be completely divided, or to the distal as well al side of the wound, if it be merely punctured.*

ciples of treatment were distinctly laid down by John Bell; but, t great Surgeon inculcated these rules of practice with great force,

Surgeons appear to have been led away by the erroneous idea of applying th Hunterian principles in the treatment of aneurism of that of wounded arteries, until Guthrie, by his practice and precepts, and by bringing an overwhelming mass of proof to bear on this important question, recalled the attention of the Profession to the proper and rational treatment of wounded arteries.

1. **That no operation ought to be performed on a wounded artery unless it bleeds.**—If by the time the Surgeon sees the patient, bleeding has ceased, however furious it may have been, and however probable it may appea from the situation of the wound that a large artery has been injured, no operation should be undertaken. The patient should be placed in bed, the wound should be dressed and a tourniquet applied loosely round the limb ready to be tightened at once should the bleeding again occur. He should b constantly watched by some competent person for the next twenty-four o forty-eight hours. If, before the Surgeon sees the case, bleeding supposed t come from a large vessel has been arrested by pressure, he should at once rela all pressure and remove the pads, as it is not safe to trust to compression fo the arrest of hæmorrhage from a vessel of any magnitude. If, on doin this, bleeding occurs, he must be guided in his treatment by the two followin rules. If no hæmorrhage appears, he must follow the directions just give The reason for this rule is that a small artery, especially when wounded nea its parent trunk, may for a time pour forth such an amount of blood as t make it appear as if the main trunk itself was implicated, and yet may safel be closed by the processes of natural arrest already described. A man wa brought to the University College Hospital with a deep stab in the groi directly in the course of the external iliac artery; a very large quantity o arterial blood had been lost, but the hæmorrhage was arrested on his admissio by the application of pressure, &c. From the great and sudden loss of blo it was supposed that the external iliac had been punctured, but it was no thought advisable to perform any operation unless hæmorrhage recurre The bleeding did not return, and the wound healed without any further troubl

This rule, as will subsequently be shown, does *not* apply to seconda hæmorrhage, nor to bleeding from vessels opened by ulceration or sloughing

2. **To expose the vessel at the wounded part and to tie it ther** —The principal reason for this rule is, that a ligature of the main trunk at distance above the wound stops only the direct supply of blood to the lim but does not interfere with the indirect or anastomosing circulation, by whic means the blood readily passes into that portion of the vessel which is beyon the ligature, and may, if the anastomosis be very free, continue to escape fro the divided artery. Thus, though bright arterial blood may no longer j from the wound, a continuous stream of the same colour, or of a darker tint it has become partially deoxygenated in its passage through the anastomosin channels, will continue to well out. This may come from the proximal or th distal end, or from both, but most commonly from the distal end only. If th anastomosis is less free, ligature at a distance on the proximal side ma temporarily arrest the hæmorrhage by the formation of a clot at the seat of th but as the anastomosing circulation becomes fully established and th essure increases, the clot is forced out and hæmorrhage recommence a Surgeon endeavours to arrest the flow of blood from a wound of th ery near the palm by a ligature applied to the brachial in the midd

of the arm, and, when the blood bursts forth as furiously as ever, applies successive ligatures to the arteries of the forearm with as little success, he will at last, on account of the continual recurrence of hæmorrhage, be forced to adopt the simple expedient that ought to have been had recourse to in the first instance, namely, that of ligaturing the vessel at the point wounded.

Another reason for the practice now advocated is, that in some cases the Surgeon cannot possibly know what artery is injured unless he seek for it in the wound itself. A large artery may, from the direction of the stab and the impetuous flow of blood that has followed it, appear to be wounded, when in reality it is only a minor branch that has been injured. Thus, for instance, in hæmorrhage from a stab in the axilla, which proved fatal notwithstanding the ligature of the subclavian artery for supposed wound of the axillary, the long thoracic was found to be the vessel divided; so, also, the external iliac artery has been ligatured for supposed wound of the common femoral, when in reality it was the external pudic that was injured.

Lastly, when the main artery of a limb is wounded, if ligature of the trunk in its continuity on the proximal side of the wound should by any chance succeed in arresting the bleeding, the vessel is obliterated at two points—at the seat of ligature and at the wound—and, consequently, gangrene is very likely to occur as the blood may have to pass through two sets of anastomosing vessels to reach the parts below the wound.

This rule applies to every case in which it is possible to expose the wounded vessel sufficiently to apply a ligature to it. The only exceptions are wounds of certain of the deep branches of the carotid and some cases of wound of the deep palmar arch (see Chapter XVI). As will be seen hereafter it applies to secondary as well as to primary hæmorrhage.

3. The third great principle in the treatment of wounded arteries is, that **a ligature is to be applied to both ends of the vessel, if it be completely cut across; or on both sides of the aperture in it, if it be only partially divided.**

The reason for this rule of practice is founded on physiological grounds as well as on practical experience. If the anastomoses of the part be very free, as in the arteries of the palm or forearm, bleeding may continue from the distal end, uninterrupted by the ligature on the proximal side of the wound; if they be less free, a stream of dark-looking venous blood will probably issue in the course of two or three days. After the collateral circulation has been sufficiently established, bright scarlet blood will burst forth from the distal aperture. Experience has shown that it is in this way that secondary hæmorrhage from wounded arteries commonly occurs, the bleeding coming from the distal and not from the proximal end of the vessel.

In some cases the distal end is so retracted and covered in by surrounding parts, that it cannot be found in order to be ligatured. In these circumstances, if it is not actually bleeding, it may be left alone in the hope that hæmorrhage will not occur. If, however, it be bleeding, a graduated compress must be applied, but such means should never be resorted to until the wound has been freely enlarged and a thorough search made for the vessel. If an arterial branch happen to be divided so close to its origin that it cannot be secured, the case must be treated as one of puncture of the main trunk, which must be ligatured above and below the bleeding orifice.

Mode of Operating.—In order to arrest the hæmorrhage during the

operation a tourniquet should be applied if the wounded vessel is in one of the limbs. A screw tourniquet will usually be found most convenient, as it can be relaxed in order to guide the Surgeon to the wound when the vessel is exposed, and again tightened with little loss of time. It is more effectual and certain than digital compression by an Assistant. It will often be found a great assistance to the Surgeon if the limb be rendered bloodless by Esmarch's method before commencing the operation. While this is being done the hæmorrhage must be arrested by digital compression at the most convenient point above the wound. When the wound is in such a situation that a tourniquet cannot be applied, digital compression by an assistant must necessarily be relied on. Hæmorrhage having been temporarily arrested by one of the above means, a large probe should be passed to the bottom of the wound ; and, taking this as the centre, a free incision should be made in such a direction as will best lay open the cavity with the least injury to the muscles and other soft parts. After turning out any coagula contained in the wound, and clearing it as well as possible, the injured vessel must be sought for. The situation of this may sometimes be ascertained at once by the gaping of the cut in its coats ; but, in many cases, it is necessary to relax the pressure upon the artery, so as to allow a jet of blood to escape, and thus indicate the position of the aperture. If the vessel be only partially divided it must be cleaned in the way already described when treating of ligature of arteries in their continuity, and a ligature passed by means of an aneurism needle above and below the wound. When these are tied it is safer to divide the vessel completely at the site of the wound. If the vessel has been completely cut across, each end must be found and drawn forward with the artery forceps and tied as in an open wound. This operation is not always so easy in practice as it seems in description. The artery, if completely divided, retracts considerably, and it is often difficult to find the ends in the midst of the areolar tissue infiltrated and stained with blood. Under these circumstances a portion of the sheath thickened by adherent coagulum may be mistaken for the artery. The proximal end is most commonly found with little difficulty by allowing a jet of blood to escape from it. The distal end may not be bleeding at the time of the operation, though blood would probably escape from it as soon as the anastomosing circulation became established. It can then only be found by a careful search guided by accurate anatomical knowledge.

The artery is usually reached most easily by enlarging the original wound in the parts superficial to it, but Guthrie advises that, in those cases in which the wound passes indirectly to the principal artery from the back or outside of the limb, the Surgeon instead of following the track of the wound, shall cut down on the vessel where it lies nearest the surface ; then, on passing a probe through the wound, the spot at which the artery has probably been injured will be pointed out, and the ligature must then be applied in the way usual in cases of primary hæmorrhage.

ACCIDENTS AFTER ARTERIAL OCCLUSION BY SURGICAL MEANS.

T [illegible] that may follow the arrest of primary hæmorrhage from a [illegible] are Intermediate or Reactionary Hæmorrhage, Secondary or [illegible]rhage, and Gangrene of the Limb.

rmediate or Reactionary Hæmorrhage.—This term is limited to hage occurring within twenty-four hours of the wound of the vessel. commonly occurs within twelve hours of the infliction of the injury.

es.—At the end of an operation the patient is often faint from the ed shock, loss of blood, and the depressing influence of the anæsthetic; ame time the exposure of the wound to the air, and the mechanical s of the knife and the sponges, have caused the greatest possible degree action of the mouths of the wounded vessels. Under these circum- vessels of considerable size may not yield a drop of blood. As soon as nd is closed, however, and warmly dressed, and the patient put to bed, tness begins to pass off, the heart beats more forcibly, the contracted ilate, and hæmorrhage takes place. At the same time, if any vessel en imperfectly tied—owing to carelessness on the part of the Surgeon, e use of badly-prepared rigid catgut—the knot may yield, and the may slip off.

wound of a collateral branch above the point of application of the , though it does not bleed much at the time, will, as I have seen, cause bleeding as the collateral circulation becomes established.

nomena.—As the bleeding comes as a rule only from the smaller it is seldom very profuse. It usually distends the wound, tightening hes, and causing the patient considerable pain.

tment.—Stimulants should be avoided as far as possible during the hours after an operation, so that recovery from shock may be gradual. l treatment is the same as that of primary hæmorrhage. If the oozing slight, the part may be raised and gentle pressure applied; if more t, the wound must be opened up, and the bleeding vessel secured. If nd is much distended by clots, the pressure thus produced may arrest ding; but it is better for the patient under these circumstances to the wound, turn out the clots, and secure any vessel that may be s the mass of coagulum between the surfaces would form a serious to union by the first intention.

an operation the patient be very faint, and the smaller arteries which e expected to bleed cannot be found, they may sometimes be made t by bathing the wound with carbolic lotion or some other antiseptic at a temperature of about 98° Fahr. In private practice it is better l operations if possible early in the morning, so that if reactionary hage should occur, it may take place in the day and not in the night.

dary or Recurrent Hæmorrhage.—By Secondary Hæmorrhage t bleeding which comes on after the employment of any of the above- ed modes of arresting hæmorrhage at any period after the first twenty- urs. This accident may arise from a variety of causes, which may be first into two great classes:—1. Constitutional Causes; and 2. Local

titutional Causes.—It has already been pointed out that the healthy of a wounded artery is a process analogous in every respect to union by ntion; the internal coagulum serving the important purpose of pro- the soft new tissue, by means of which the mouth of the wounded being closed, from the direct impulse of the wave of blood from the All those constitutional conditions which have already been described g unfavourable to union by the first intention, are therefore equally

CHAPTER XV.

TRAUMATIC ANEURISM AND ARTERIO-VENOUS WOUNDS.

TRAUMATIC ANEURISM.

We have hitherto discussed those wounds of arteries in which the blood is discharged freely from an open wound, but all cases are not so simple as these. It sometimes happens that there is a subcutaneous extravasation, forming a more or less distinct cavity, into which the blood is thrown from the wounded artery, accompanied usually by pulsation of the swelling, and occasionally by thrill and bruit. This extravasation constitutes a **Traumatic Aneurism**, and may arise in three ways: 1, The punctured wound leading to the injured artery may be oblique or indirect, and thus the blood may partly escape at the cutaneous opening, and partly be extravasated into the tissues around the vessel. 2, The puncture in the integuments may be closed by plaster, or a pad of lint and a bandage, and thus no blood may escape externally, although the wound in the artery remains patent, and blood is forced out into the substance of the part. 3, There may be no external wound, the artery being punctured or torn subcutaneously by the fragments of a fractured bone, by a violent strain, by the injury inflicted in a dislocation, or by the Surgeon in his efforts to reduce it.

Two forms of aneurism are described as arising from such injuries as the above: the diffused and the circumscribed.

Diffused Traumatic Aneurism.—This consists of an effusion of blood from a wounded or ruptured artery, limited in extent by the resistance of the surrounding parts. In the immediate neighbourhood of the opening in the vessel there is an ill-defined cavity communicating with the artery formed by the separation of the surrounding parts by the pressure of the blood. There is no true sac, and such boundary as there may be is formed partly by coagulum, and partly by the surrounding fasciæ, muscles and other structures more or less matted together by inflammatory exudation. The extravasation continues to increase and to force its way amongst the tissues of the part until the resistance offered by the stretched and distended structures is equal to the pressure in the injured artery.

The effects of subcutaneous arterial hæmorrhage necessarily vary with the size of the artery, the nature of the wound, and the laxity of the surrounding parts. Thus, if the axillary artery be lacerated in the attempted reduction of an old dislocation of the shoulder-joint, the axilla, the loose tissue beneath the pectoral muscles and in the root of the neck, may be tensely distended with extravasated blood in a few minutes, while in a punctured wound of a deep-seated smaller vessel, such as the posterior tibial, many hours or even days may elapse before the extreme limit of distension of the surrounding parts has been reached. Many Surgeons, with much reason, object to the use of ...rd "aneurism" in connection with the more rapid arterial extravasations,

clean an artery perfectly, even when using an absorbable ligature. Secondary hæmorrhage may result from sloughing of the vessel, if, in the process of cleaning it for passing the ligature, it be too widely separated from the sheath.

3. *Causes dependent upon the anatomical conditions of the artery at the point ligatured.*—The *rush of blood through a neighbouring trunk or collateral branch* immediately above the ligature has been considered likely to interfere with the formation of the internal coagulum ; but too much importance should not be attached to this, for Porter tied the carotid successfully within one-eighth of an inch of the brachio-cephalic artery ; Bellingham ligatured the external iliac close to its origin ; and Aston Key, the subclavian in the vicinity of a large branch, without secondary hæmorrhage ensuing. But although the ligature may be safely applied near a branch on its proximal side, I think that the presence of a collateral branch in close proximity to the *distal* side of the ligature—more especially if it be one that serves to carry on the anastomosing circulation—will be found to have a decided tendency to prevent the occlusion of the distal end of the artery, and thus to favour the occurrence of secondary hæmorrhage.

Bleeding, resembling true secondary hæmorrhage, may occasionally take place some days after the artery is tied, when the collateral circulation is fully established, if the Surgeon have neglected to secure the distal as well as the proximal end.

4. *Pathological conditions of the coats of the artery.*—Chronic endarteritis and calcification of the arterial wall were very important elements in the causation of secondary hæmorrhage after the use of the irritating separable ligature ; the process of repair was interfered with and the ligature separated prematurely. The danger is much less with aseptic absorbable ligatures, especially if they be tied with division of the inner and middle coats.

Fatal secondary hæmorrhage has occurred from a large artery, such as the femoral, in consequence of a small atheromatous or calcareous patch having given way immediately above the ligature a day or two after its application.

5. *Unhealthy processes occurring in the wound.*—The extreme rarity of secondary hæmorrhage after operations at the present day is undoubtedly due to the use of aseptic absorbable ligatures, and the prevention of unhealthy changes in the wound. By these means, and by the use of torsion, favourable results are now obtained, even though many of the other predisposing causes of secondary hæmorrhage be present. The occurrence of suppuration around the injured part of the artery necessarily interferes with that healthy process of repair by which the hæmorrhage is permanently arrested. Severe secondary hæmorrhage may occur, especially after gun-shot wounds, as the result of sloughing of the wall of an artery which was bruised, but not actually torn, by the injury.

Phenomena.—The occurrence of secondary hæmorrhage is usually somewhat gradual, and not without warning. The blood does not burst forth in a sudden gush, but appears at first in small quantity, oozing out of the wound and staining the dressings ; it may then cease to flow for a time, probably from the opening in the artery becoming plugged by a piece of clot, but it breaks out again in the course of a few hours, welling up freely in the wound, and either exhausting the patient by repeated losses, or else debilitating him so that he falls a victim to some secondary disease, such as pneumonia, erysi-

pelas, or pyæmia. In other cases again, after a few warnings, the blood may burst out in a gushing stream that quickly destroys life.

The opportunities which I have had of examining the state of the vessels in several cases of fatal secondary hæmorrhage, lead me fully to concur with Guthrie and Porter, that when hæmorrhage occurs from an artery ligatured in its continuity, *the blood in the great majority of instances comes from the distal and not from the proximal side of the wound.* The greater tendency in the distal end of the vessel to bleed, appears to arise partly from the less perfect occlusion of this portion of the artery, and partly from its greater liability to slough, in consequence of the ligature interrupting its supply of blood through the vasa vasorum. It is no objection to this opinion that the hæmorrhage is often arterial; for, though it is true that the blood which is carried to the distal end is, for the first few days after the application of a ligature, of a venous hue, yet, after the collateral circulation is freely established, it assumes a more scarlet tint, and at last becomes completely arterial.

Period at which it occurs.—Secondary hæmorrhage may occur at any time from twenty-four hours after the operation to the closure of the wound.

When the *separable ligature* was used, it was particularly apt to occur about the period of the separation of the ligature, as the result of any of the causes already specified which interfere with the formation of the internal coagulum, or that occasion ulceration and sloughing of the coats of the vessel. At a later period it might also arise when the wound remained open, as the result of the presence of a slough where the noose of the ligature had lain, or from insufficient drainage of the suppurating track left by the ligature.

In St. Thomas's Hospital is a preparation of a carotid artery, from which secondary hæmorrhage took place in the tenth week after ligature; and South mentions a case of ligature of the subclavian in which the thread separated on the twenty-seventh day, the fatal hæmorrhage occurring in the thirteenth week.

When an *absorbable ligature* is used, secondary hæmorrhage may very rarely occur on the third or fourth day, from premature softening of imperfectly prepared catgut, if that material be employed. Should the ligature be septic, or become so by contamination from the wound, it may behave exactly as the old separable ligature, and secondary hæmorrhage result from similar causes and at similar periods.

Prevention of Secondary Hæmorrhage.—In all cases in which a large artery has been wounded, or tied in its continuity, care should of course be taken to prevent this accident, if possible, by keeping the patient perfectly quiet, avoiding undue stimulation, and keeping the bowels open. A patient once nearly died in University College Hospital from secondary hæmorrhage which commenced while she was straining violently at stool. When there is marked arterial tension with a full and rapid pulse it may sometimes be advisable to h[illegible]ourse to venesection if from the state of the wound there is any spe[illegible]ear secondary hæmorrhage. Of all means of avoiding this ac[illegible] the prevention of septic processes in the wound is by far [illegible]t. Secondary hæmorrhage may be said never to occur in a [illegible]althily without suppuration. Should suppuration occur and

ound open up so that the main vessels can be seen beating forcibly, the r of the patient is great. He should then be carefully watched, the diet be lowered, and the artery compressed digitally at the most convenient above the wound.

EATMENT OF SECONDARY ARTERIAL HÆMORRHAGE.—In this we are d by two definite rules to which there are few exceptions: 1. *That even hæmorrhage have ceased spontaneously, operative interference is necessary event its return;* and, 2. *That the means of arresting the hæmorrhage d, if possible, be applied at the bleeding point.* These principles are now st universally recognised, and form the only safe guide in the treatment is most anxious complication.

That even if the hæmorrhage have ceased spontaneously, opera- interference is necessary to prevent its return.—This rule, it will bserved, is the reverse of that by which we are guided in primary rrhage. It is founded on our knowledge of the phenomena of secondary rrhage as described on p. 455. After the first outbreak, even though leeding may cease for a time, it is almost certain to recur. When a ition of secondary hæmorrhage has taken place, the patient's condition nes most critical; the efforts of nature can no longer be relied on to the bleeding, and the fatal gush may recur at any moment. In rcumstances are more coolness and more surgical knowledge required, in adopting a decisive and immediate line of action in a case of dary hæmorrhage. There is no time for delay, no time for consultation, for reference to books; the Surgeon must act at once on his own nsibility.

e only exception to this first rule is when the hæmorrhage occurs r days after the operation, and is very small in quantity, amounting more than a slight oozing. Under these circumstances, elevation e part, the application of cold and moderately firm bandaging over ton-wool or other elastic dressing, so as to press the surfaces of the d against each other, will sometimes arrest the bleeding. If the g continue, however, more efficient means must be adopted without

That the means of arresting hæmorrhage should, if possible, pplied at the bleeding-point.—This rule is the same as that for g with primary hæmorrhage. The following are the chief reasons upon it is founded. *First*, until the wound is opened up it is impossible to om what vessel the bleeding proceeds. Thus after amputation of the it may come from branches of the profunda or from the superficial al. In some cases it may happen that no large vessel is bleeding, the rrhage proceeding from the soft granulation-tissue lining an unhealthy . In 1866 a man was admitted into University College Hospital under re on account of very serious secondary hæmorrhage from a gun-shot d on the inner side of the arm, exactly in the line of the brachial artery, which it was supposed to proceed. The wound was freely enlarged and cavity was exposed lined with soft unhealthy granulation-tissue, but no vessel was found to be bleeding. The cavity was cleaned out and the ing did not recur. Twenty years afterwards the man was admitted for er accident, and the brachial artery could then be seen running close to ar and evidently uninjured. *Secondly.*—If the main trunk be tied at a

artery, met with in the dissecting-room of University College, a tortuous vessel, about the size of a crow-quill, and measuring, when straightened out, nine inches in length, was found passing from the internal mammary in the third intercostal space to the external mammary branch of the axillary. Occasionally a number of such arteries may form an interlacement. The anastomosing arteries that carry on the circulation are, as a rule, easily dissected out in a well-injected subject in the dissecting-room, and at one time it was supposed that it was not safe to tie a large artery except in those situations in which such easily demonstrable anastomoses exist. Thus, for instance, after the ligature of the common carotid, the supply of blood is ultimately conveyed by the inosculations between the superior and inferior thyroid arteries and by the vertebral. When the subclavian is tied the circu-

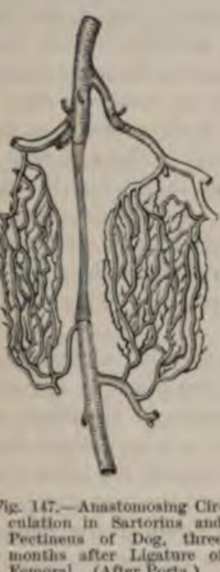

Fig. 147.—Anastomosing Circulation in Sartorius and Pectineus of Dog, three months after Ligature of Femoral. (After Porta.)

Fig. 148.—Direct Anastomosing Vessels of Right Carotid of Goat, five months after Ligature. (After Porta.)

Fig. 149.—Change in the Trunk after Ligature; with Anastomosing Vessel.

lation of the upper extremity is carried on by the anastomosis of the posterior scapular and suprascapular from the thyroid axis, with the acromio-thoracic and subscapular of the axillary, of the branches of the internal mammary and intercostal arteries with the external mammary of the axillary, and of the superior intercostal of the subclavian with the superior thoracic of the axillary; and when the external iliac is tied, the blood is conveyed to the lower limb by the inosculations between the internal mammary and lumbar arteries and the epigastric and circumflex ilii, and by those between the obturator, gluteal, and sciatic arteries, and the circumflex branches of the profunda femoris.

It has, however, repeatedly been shown that the ordinary muscular and subcutaneous vessels of the part are amply sufficient to carry on the circulation, even when no anastomosing arteries can be demonstrated by dissection.

sion in all directions. Pulsation may, however, be absent. This occurs when the sac is ill-defined and contains much coagulum, and when the cavity is very large in proportion to the artery communicating with it. In spite of the absence of pulsation, such aneurisms continue to increase in size, and may finally rupture, but before doing so the superficial parts covering the tumour become inflamed from the tension. Such non-pulsating inflamed aneurisms are readily mistaken for abscesses. A bruit may often be heard in a circumscribed traumatic aneurism, but it is frequently absent. As the tumour increases in size, it will give rise to pressure signs similar to those of a spontaneous aneurism. (See Chap. XLIII., Vol. II.) This form of traumatic aneurism most commonly occurs from wounds partially dividing small arteries, as the temporal, plantar, palmar, radial, and ulnar, but it is also met with in connection with the larger vessels as a consequence of very small punctured wounds.

The **Treatment** must depend on the size and the situation of the artery, and on the degree of definition of the sac. The less defined the sac, that is to say, the more closely the tumour approaches a diffused aneurism, the more imperative it is to treat it by laying open the sac and ligaturing above and below the opening, as described before (p. 466). On the other hand, if the sac be well defined, treatment by compression of the vessel leading to it may be attempted, and is occasionally successful. When this has failed, the operation by laying open the sac is usually to be preferred. The profuse suppuration from the cavity, which was formerly so troublesome, can usually be prevented by clearing away all coagula with a sharp spoon, and adopting efficient antiseptic treatment. In this way, in a case of traumatic aneurism of the ulnar artery in which the sac was as big as a large orange, complete union by first intention was obtained, the two sides of the sac adhering when brought together. In exceptional cases, if the sac be well-defined, and the tumour be so situated that it would be difficult or hazardous to lay it open, a proximal ligature may be applied; but there is no necessity in most cases to tie at a distance from the sac, as the vessel is healthy except at the wounded spot. Thus, to avoid cutting into the palm, which might have endangered the utility of the hand, I successfully tied the brachial for the aneurism represented in Fig. 150, which followed an injury from a powder-flask explosion. When the aneurism shows signs of impending suppuration the proper course is to lay open the sac and tie above and below.

Fig. 150.—Circumscribed Traumatic Aneurism in Ball of Thumb after a Powder-flask Explosion.

2. The next form of circumscribed traumatic aneurism is of rare occurrence, and arises usually from a small puncture in a large artery. The vessel bleeds freely; but, the hæmorrhage being arrested by pressure, the external wound, and that in the artery close. The cicatrix in the artery gradually yields, forming, at the end of weeks or months, a tumour which gradually enlarges, and pulsates eccentrically, with distinct bruit, having all the symptoms that characterize an aneurism from disease, and possessing a sac continuous with

Surgeons appear to have been led away by the erroneous idea of applying the Hunterian principles in the treatment of aneurism of that of wounded arteries, until Guthrie, by his practice and precepts, and by bringing an overwhelming mass of proof to bear on this important question, recalled the attention of the Profession to the proper and rational treatment of wounded arteries.

1. **That no operation ought to be performed on a wounded artery unless it bleeds.**—If by the time the Surgeon sees the patient, bleeding has ceased, however furious it may have been, and however probable it may appear from the situation of the wound that a large artery has been injured, no operation should be undertaken. The patient should be placed in bed, the wound should be dressed and a tourniquet applied loosely round the limb, ready to be tightened at once should the bleeding again occur. He should be constantly watched by some competent person for the next twenty-four or forty-eight hours. If, before the Surgeon sees the case, bleeding supposed to come from a large vessel has been arrested by pressure, he should at once relax all pressure and remove the pads, as it is not safe to trust to compression for the arrest of hæmorrhage from a vessel of any magnitude. If, on doing this, bleeding occurs, he must be guided in his treatment by the two following rules. If no hæmorrhage appears, he must follow the directions just given. The reason for this rule is that a small artery, especially when wounded near its parent trunk, may for a time pour forth such an amount of blood as to make it appear as if the main trunk itself was implicated, and yet may safely be closed by the processes of natural arrest already described. A man was brought to the University College Hospital with a deep stab in the groin, directly in the course of the external iliac artery; a very large quantity of arterial blood had been lost, but the hæmorrhage was arrested on his admission by the application of pressure, &c. From the great and sudden loss of blood it was supposed that the external iliac had been punctured, but it was not thought advisable to perform any operation unless hæmorrhage recurred. The bleeding did not return, and the wound healed without any further trouble.

This rule, as will subsequently be shown, does *not* apply to secondary hæmorrhage, nor to bleeding from vessels opened by ulceration or sloughing.

2. **To expose the vessel at the wounded part and to tie it there.**—The principal reason for this rule is, that a ligature of the main trunk at a distance above the wound stops only the direct supply of blood to the limb, but does not interfere with the indirect or anastomosing circulation, by which means the blood readily passes into that portion of the vessel which is beyond the ligature, and may, if the anastomosis be very free, continue to escape from the divided artery. Thus, though bright arterial blood may no longer jet from the wound, a continuous stream of the same colour, or of a darker tint if it has become partially deoxygenated in its passage through the anastomosing channels, will continue to well out. This may come from the proximal or the distal end, or from both, but most commonly from the distal end only. If the anastomosis is less free, ligature at a distance on the proximal side may temporarily arrest the hæmorrhage by the formation of a clot at the seat of the wound, but as the anastomosing circulation becomes fully established and the blood-pressure increases, the clot is forced out and hæmorrhage recommences. Thus, if a Surgeon endeavours to arrest the flow of blood from a wound of the ulnar artery near the palm by a ligature applied to the brachial in the middle

of the arm, and, when the blood bursts forth as furiously as ever, applies successive ligatures to the arteries of the forearm with as little success, he will at last, on account of the continual recurrence of hæmorrhage, be forced to adopt the simple expedient that ought to have been had recourse to in the first instance, namely, that of ligaturing the vessel at the point wounded.

Another reason for the practice now advocated is, that in some cases the Surgeon cannot possibly know what artery is injured unless he seek for it in the wound itself. A large artery may, from the direction of the stab and the impetuous flow of blood that has followed it, appear to be wounded, when in reality it is only a minor branch that has been injured. Thus, for instance, in hæmorrhage from a stab in the axilla, which proved fatal notwithstanding the ligature of the subclavian artery for supposed wound of the axillary, the long thoracic was found to be the vessel divided ; so, also, the external iliac artery has been ligatured for supposed wound of the common femoral, when in reality it was the external pudic that was injured.

Lastly, when the main artery of a limb is wounded, if ligature of the trunk in its continuity on the proximal side of the wound should by any chance succeed in arresting the bleeding, the vessel is obliterated at two points—at the seat of ligature and at the wound—and, consequently, gangrene is very likely to occur as the blood may have to pass through two sets of anastomosing vessels to reach the parts below the wound.

This rule applies to every case in which it is possible to expose the wounded vessel sufficiently to apply a ligature to it. The only exceptions are wounds of certain of the deep branches of the carotid and some cases of wound of the deep palmar arch (see Chapter XVI). As will be seen hereafter it applies to secondary as well as to primary hæmorrhage.

3. The third great principle in the treatment of wounded arteries is, that **a ligature is to be applied to both ends of the vessel, if it be completely cut across ; or on both sides of the aperture in it, if it be only partially divided.**

The reason for this rule of practice is founded on physiological grounds as well as on practical experience. If the anastomoses of the part be very free, as in the arteries of the palm or forearm, bleeding may continue from the distal end, uninterrupted by the ligature on the proximal side of the wound ; if they be less free, a stream of dark-looking venous blood will probably issue in the course of two or three days. After the collateral circulation has been sufficiently established, bright scarlet blood will burst forth from the distal aperture. Experience has shown that it is in this way that secondary hæmorrhage from wounded arteries commonly occurs, the bleeding coming from the distal and not from the proximal end of the vessel.

In some cases the distal end is so retracted and covered in by surrounding parts, that it cannot be found in order to be ligatured. In these circumstances, if it is not actually bleeding, it may be left alone in the hope that hæmorrhage will not occur. If, however, it be bleeding, a graduated compress must be applied, but such means should never be resorted to until the wound has been freely enlarged and a thorough search made for the vessel. If an arterial branch happen to be divided so close to its origin that it cannot be secured, the case must be treated as one of puncture of the main trunk, which must be ligatured above and below the bleeding orifice.

Mode of Operating.—In order to arrest the hæmorrhage during the

operation a tourniquet should be applied if the wounded vessel is in one of the limbs. A screw tourniquet will usually be found most convenient, as it can be relaxed in order to guide the Surgeon to the wound when the vessel is exposed, and again tightened with little loss of time. It is more effectual and certain than digital compression by an Assistant. It will often be found a great assistance to the Surgeon if the limb be rendered bloodless by Esmarch's method before commencing the operation. While this is being done the hæmorrhage must be arrested by digital compression at the most convenient point above the wound. When the wound is in such a situation that a tourniquet cannot be applied, digital compression by an assistant must necessarily be relied on. Hæmorrhage having been temporarily arrested by one of the above means, a large probe should be passed to the bottom of the wound; and, taking this as the centre, a free incision should be made in such a direction as will best lay open the cavity with the least injury to the muscles and other soft parts. After turning out any coagula contained in the wound, and clearing it as well as possible, the injured vessel must be sought for. The situation of this may sometimes be ascertained at once by the gaping of the cut in its coats; but, in many cases, it is necessary to relax the pressure upon the artery, so as to allow a jet of blood to escape, and thus indicate the position of the aperture. If the vessel be only partially divided it must be cleaned in the way already described when treating of ligature of arteries in their continuity, and a ligature passed by means of an aneurism needle above and below the wound. When these are tied it is safer to divide the vessel completely at the site of the wound. If the vessel has been completely cut across, each end must be found and drawn forward with the artery forceps and tied as in an open wound. This operation is not always so easy in practice as it seems in description. The artery, if completely divided, retracts considerably, and it is often difficult to find the ends in the midst of the areolar tissue infiltrated and stained with blood. Under these circumstances a portion of the sheath thickened by adherent coagulum may be mistaken for the artery. The proximal end is most commonly found with little difficulty by allowing a jet of blood to escape from it. The distal end may not be bleeding at the time of the operation, though blood would probably escape from it as soon as the anastomosing circulation became established. It can then only be found by a careful search guided by accurate anatomical knowledge.

The artery is usually reached most easily by enlarging the original wound in the parts superficial to it, but Guthrie advises that, in those cases in which the wound passes indirectly to the principal artery from the back or outside of the limb, the Surgeon instead of following the track of the wound, shall cut down on the vessel where it lies nearest the surface; then, on passing a probe through the wound, the spot at which the artery has probably been injured will be pointed out, and the ligature must then be applied in the way usual in cases of primary hæmorrhage.

ACCIDENTS AFTER ARTERIAL OCCLUSION BY SURGICAL MEANS.

The accidents that may follow the arrest of primary hæmorrhage from a wounded artery are Intermediate or Reactionary Hæmorrhage, Secondary or Recurrent Hæmorrhage, and Gangrene of the Limb.

Intermediate or Reactionary Hæmorrhage.—This term is limited to hæmorrhage occurring within twenty-four hours of the wound of the vessel. It most commonly occurs within twelve hours of the infliction of the injury.

Causes.—At the end of an operation the patient is often faint from the combined shock, loss of blood, and the depressing influence of the anæsthetic; at the same time the exposure of the wound to the air, and the mechanical stimulus of the knife and the sponges, have caused the greatest possible degree of contraction of the mouths of the wounded vessels. Under these circumstances, vessels of considerable size may not yield a drop of blood. As soon as the wound is closed, however, and warmly dressed, and the patient put to bed, the faintness begins to pass off, the heart beats more forcibly, the contracted vessels dilate, and hæmorrhage takes place. At the same time, if any vessel have been imperfectly tied—owing to carelessness on the part of the Surgeon, or to the use of badly-prepared rigid catgut—the knot may yield, and the ligature may slip off.

The *wound of a collateral branch* above the point of application of the ligature, though it does not bleed much at the time, will, as I have seen, cause furious bleeding as the collateral circulation becomes established.

Phenomena.—As the bleeding comes as a rule only from the smaller vessels, it is seldom very profuse. It usually distends the wound, tightening the stitches, and causing the patient considerable pain.

Treatment.—Stimulants should be avoided as far as possible during the first few hours after an operation, so that recovery from shock may be gradual. The local treatment is the same as that of primary hæmorrhage. If the oozing be very slight, the part may be raised and gentle pressure applied; if more abundant, the wound must be opened up, and the bleeding vessel secured. If the wound is much distended by clots, the pressure thus produced may arrest the bleeding; but it is better for the patient under these circumstances to open up the wound, turn out the clots, and secure any vessel that may be found, as the mass of coagulum between the surfaces would form a serious obstacle to union by the first intention.

If at an operation the patient be very faint, and the smaller arteries which might be expected to bleed cannot be found, they may sometimes be made apparent by bathing the wound with carbolic lotion or some other antiseptic solution at a temperature of about 98° Fahr. In private practice it is better to do all operations if possible early in the morning, so that if reactionary hæmorrhage should occur, it may take place in the day and not in the night.

Secondary or Recurrent Hæmorrhage.—By Secondary Hæmorrhage is meant bleeding which comes on after the employment of any of the above-mentioned modes of arresting hæmorrhage at any period after the first twenty-four hours. This accident may arise from a variety of causes, which may be divided first into two great classes:—1. Constitutional Causes; and 2. Local Causes.

Constitutional Causes.—It has already been pointed out that the healthy closure of a wounded artery is a process analogous in every respect to union by first intention; the internal coagulum serving the important purpose of protecting the soft new tissue, by means of which the mouth of the wounded vessel is being closed, from the direct impulse of the wave of blood from the heart. All those constitutional conditions which have already been described as being unfavourable to union by the first intention, are therefore equally

unfavourable to the closure of a wounded artery, and consequently act as predisposing causes of secondary hæmorrhage. In some cases of *septicæmia* and in *pyæmia* the blood is found to coagulate imperfectly, and in these the internal coagulum may be more or less completely wanting, thus exposing the feeble granulation-tissue, closing the vessel, to the direct impulse of blood from the heart. In such cases, even if a clot of blood does form at first, it is liable to disintegrate and to be washed away.

In some cases secondary hæmorrhage appears to be in part due to the *forcible and excited action of the heart during the early stages of traumatic fever.* The patient is restless, and the pulse quick and bounding. In such circumstances if the bleeding be not too profuse, it sometimes appears to give relief to the symptoms.

Chronic Bright's disease, with increased arterial tension and hypertrophy of the heart, sometimes acts as a predisposing cause of secondary hæmorrhage, which is also more likely to occur in plethoric subjects, than in those of a more spare habit.

Local Causes.—These may be thus divided :—

1. *Causes dependent on the Ligature.*—A silk or hemp ligature applied in such a way as to cut through the arterial coats and to come away from the wound, necessarily excited inflammation, reaching the stage of suppuration, and maintained the process till it had cut through the vessel by ulceration. The extent of the inflammation depended to some degree upon the size of the ligature. If it were very fine and well waxed so as to be almost non-absorbent the inflammation was accurately limited to the parts in contact with the thread. If, however, it were thick and soaked in decomposing discharges, the inflammation extended more widely and interfered with the proper development of the granulation-tissue closing the divided inner and middle coats ; consequently as soon as the process of ulceration had perforated the external coat, hæmorrhage occurred. It had long been recognized that the finer the ligature, the more safely did it occlude the vessel, provided it were of sufficient strength to divide the inner and middle coats when tightened. The thicker the ligature, the more irritation it caused, and the more speedily it ulcerated through the external coat of the artery.

If the ligature be absorbable it should, as before stated, give rise to no suppuration in its immediate neighbourhood. It may, however, prove irritating, if it be improperly prepared, or if it be allowed to come in contact with decomposing discharges. Some of the absorbable ligatures also present the danger of premature softening, in consequence of which the support of the constricted external coat is taken away from the soft new tissue closing the vessel, before it is sufficiently strong to resist the blood-pressure within the artery.

2. *Causes dependent on the mode of application of the ligature.*—If the artery were insufficiently cleaned, and other structures, as pieces of muscle or a neighbouring nerve, were included in a non-absorbable ligature, the vessel was seldom safely occluded ; first, because its coats were not properly divided, and secondly, because of the more extensive sloughing and ulceration resulting from the inclusion of so large a mass in the noose of the ligature. With absorbable ligatures the dangers arising from imperfect cleaning are much less, as the ligature does not separate by ulcerating through the mass included in its noose ; but no Surgeon would on this account relax his endeavours to

clean an artery perfectly, even when using an absorbable ligature. Secondary hæmorrhage may result from sloughing of the vessel, if, in the process of cleaning it for passing the ligature, it be too widely separated from the sheath.

3. *Causes dependent upon the anatomical conditions of the artery at the point ligatured.*—The *rush of blood through a neighbouring trunk or collateral branch* immediately above the ligature has been considered likely to interfere with the formation of the internal coagulum; but too much importance should not be attached to this, for Porter tied the carotid successfully within one-eighth of an inch of the brachio-cephalic artery; Bellingham ligatured the external iliac close to its origin; and Aston Key, the subclavian in the vicinity of a large branch, without secondary hæmorrhage ensuing. But although the ligature may be safely applied near a branch on its proximal side, I think that the presence of a collateral branch in close proximity to the *distal* side of the ligature—more especially if it be one that serves to carry on the anastomosing circulation—will be found to have a decided tendency to prevent the occlusion of the distal end of the artery, and thus to favour the occurrence of secondary hæmorrhage.

Bleeding, resembling true secondary hæmorrhage, may occasionally take place some days after the artery is tied, when the collateral circulation is fully established, if the Surgeon have neglected to secure the distal as well as the proximal end.

4. *Pathological conditions of the coats of the artery.*—Chronic endarteritis and calcification of the arterial wall were very important elements in the causation of secondary hæmorrhage after the use of the irritating separable ligature; the process of repair was interfered with and the ligature separated prematurely. The danger is much less with aseptic absorbable ligatures, especially if they be tied with division of the inner and middle coats.

Fatal secondary hæmorrhage has occurred from a large artery, such as the femoral, in consequence of a small atheromatous or calcareous patch having given way immediately above the ligature a day or two after its application.

5. *Unhealthy processes occurring in the wound.*—The extreme rarity of secondary hæmorrhage after operations at the present day is undoubtedly due to the use of aseptic absorbable ligatures, and the prevention of unhealthy changes in the wound. By these means, and by the use of torsion, favourable results are now obtained, even though many of the other predisposing causes of secondary hæmorrhage be present. The occurrence of suppuration around the injured part of the artery necessarily interferes with that healthy process of repair by which the hæmorrhage is permanently arrested. Severe secondary hæmorrhage may occur, especially after gun-shot wounds, as the result of sloughing of the wall of an artery which was bruised, but not actually torn, by the injury.

Phenomena.—The occurrence of secondary hæmorrhage is usually somewhat gradual, and not without warning. The blood does not burst forth in a sudden gush, but appears at first in small quantity, oozing out of the wound and staining the dressings; it may then cease to flow for a time, probably from the opening in the artery becoming plugged by a piece of clot, but it breaks out again in the course of a few hours, welling up freely in the wound, and either exhausting the patient by repeated losses, or else debilitating him so that he falls a victim to some secondary disease, such as pneumonia, erysi-

to allow of the temporary arrest of the bleeding by digital pressure below the carotid tubercle, this should be at once done. The wound must then be enlarged, and if possible, the artery tied above and below the bleeding point, parts of one or more of the transverse processes being removed, if necessary. Failing this, the Surgeon must resort to careful plugging of the wound, or he may be able to seize the bleeding vessel in forcipressure-forceps and leave them *in situ* for several days.

Traumatic Aneurism of the Vertebral Artery has been recorded in twenty cases by Matas, of which six recovered, one of these being a case of his own, in which the sac was freely laid open in the suboccipital region and the hæmorrhage successively arrested by plugging. This treatment would appear to give the best hope of success, if digital compression of the artery and direct pressure on the aneurism fail to produce a cure.

VESSELS OF THE TRUNK.

INTERNAL MAMMARY.—Wounds of this artery rarely come under treatment, as its course lies chiefly in front of the heart and great vessels, so that penetrating wounds implicating it are usually immediately fatal from injury to the parts beneath. The *treatment*, in case the patient escapes fatal injuries to deeper parts, is to tie the artery at the wounded spot, if necessary removing a costal cartilage in order to expose it. No other treatment is likely to arrest the bleeding, because of the free anastomoses with the intercostals.

INTERCOSTAL ARTERIES.—These are rarely wounded except in gunshot wounds or stabs fracturing a rib. The hæmorrhage is seldom severe; but should it require *treatment*, the lower border of the rib corresponding to the artery must be exposed by a free incision. On removing the fragments the bleeding artery may come into view, and can be twisted or tied; or it may be turned out of its groove by means of a periosteal elevator, and sufficiently exposed to be tied. If necessary, a piece of rib may be removed to lay bare the vessel more fully. As a temporary means, pressure can be applied thus:—A piece of linen is to be pushed through the wound into the pleural cavity, so as to form a pocket; inside a sufficient quantity of lint or tow is pushed into the pocket to make it too large to pass out by the intercostal space; it is then forcibly pulled upon by the part of the linen outside the chest-walls, and secured in position by a couple of pins pushed across on a level with the skin.

VESSELS OF THE UPPER LIMB.

SUBCLAVIAN ARTERY.—**Wounds of the Subclavian Artery** are almost invariably fatal; though, owing to the protection afforded by the clavicle, they rarely occur except from gunshot injuries or stabs. From the rapidly fatal nature of wounds of the subclavian artery, **Traumatic Aneurisms** in this situation are not met with; but where the artery passes into the axilla below the margin of the first rib, they are not unfrequent.

Aneurismal Varix, resulting from wound of the *Subclavian Artery and Vein*, has been seen, notwithstanding the separation that exists between the two vessels throughout their whole extent. These injuries have likewise usually been the result of sword-thrusts, and do not admit of any surgical interference.

Axillary Artery.—In **Open Wounds of the Axillary Artery and its Branches,** the rule of practice is to expose the bleeding vessel and tie it on each side of the wound. The branches of the artery are so numerous that there must always be some uncertainty, in a case of punctured wound, whether the main trunk or a branch is injured, even when the direction of the wound and the abundance of the bleeding would suggest the former. This doubt can be cleared up only by exposing the bleeding point, and in order to do this efficiently, it may sometimes be necessary to divide both the pectoral muscles across the line of their fibres.

In secondary hæmorrhage, the state of the parts may be such as to make it very difficult to expose the artery cleanly in the wound, and the temptation to apply a proximal ligature under these circumstances is very strong, but this should never be done before a thorough attempt has been made to tie the vessel at the bleeding point, by freely opening up the wound and enlarging it, if necessary. The anastomoses between the branches of the subclavian and the axillary are so free that ligature of the third part of the subclavian is extremely likely to fail. Ligature of the first part of the axillary artery would, in a case of secondary hæmorrhage, be just as difficult as exposing the bleeding point, and could be done after division of the pectoralis major and minor, should it be impossible to secure the vessel at the wounded point. In a case of secondary hæmorrhage, the ligature of the first part of the axillary by a curved incision below the clavicle, as described in Chap. XLIV., Vol. II., would be most difficult; as the axilla would probably be filled with extravasated blood, and the parts matted together by the inflammation and suppuration which caused the failure in the repair of the artery. In all cases of secondary hæmorrhage, it would be safer to expose the artery by an incision in the line of the vessel dividing the pectoral muscles. The subclavian must be tied above the clavicle only as a last resource. The operation has been attended with success enough to justify its adoption should other means fail. Of 15 cases in which it has been performed for hæmorrhage from wounds in the axilla or from stumps, I find that 9 were cured and 6 died.

Traumatic Aneurism in the Axilla may arise from gunshot wounds or stabs, or in some cases from subcutaneous rupture of the vessel. In the latter case the patient while straining his arm in a raised position feels a sudden snap, which is rapidly followed by a large extravasation of blood in the axilla, forming the so-called diffused traumatic aneurism.

There are more than 40 cases on record in which axillary aneurism has followed an injury to the vessel occurring during the reduction of a dislocation. In only a few of these has the dislocation been recent. Amongst these is one recorded by Warren in which the vessel was ruptured in consequence of the Surgeon using his foot in the axilla as a fulcrum, but without taking off his boot. In the great majority of cases the dislocation has been of old-standing, and considerable force has been used. Gibson has related three cases of rupture of the artery in the attempt to reduce such cases by the pulleys. Pelletan mentions a case in which the rapid swelling following the rupture of the artery was mistaken for emphysema from fractured ribs. An incision was made into it and the patient bled to death. These cases show the necessity for great caution in the use of powerful extending force in the reduction of old dislocations, when adhesions may have formed between the artery and the head of the bone.

distance on the proximal side, if the operation succeeds in arresting the bleeding, the artery will be obliterated in two places, at the seat of ligature and at the wound, and, for the reasons already given, gangrene is very likely to occur. *Thirdly.*—If the anastomosing circulation is so free that gangrene does not occur, it is very probable that the operation of ligature at a distance would fail to arrest the bleeding. *Fourthly.*—The ligature of the main trunk on the proximal side involves the performance of a serious operation on a patient in a most unfavourable condition from loss of blood and septic fever, and possibly also from some infective process such as erysipelas, hospital gangrene, or pyæmia. *Fifthly.*—As secondary hæmorrhage almost invariably occurs as a consequence of septic inflammation and suppuration in the wound, the patient's condition is usually improved by opening it up and cleaning it out with some efficient antiseptic. For this reason the patient will in most cases be benefited by the attempt to secure the bleeding vessel in the wound, even if the operation cannot be completed, and the Surgeon is driven as a last resource to tie the vessel at a distance on the proximal side.

The only argument of any weight which has been brought forward against the rule of operating at the bleeding point is that as the first ligature has failed, probably from the unhealthy condition of the wound, the second ligature is likely to fail also from the same cause, and that if, in order to reach a healthy part, the artery is exposed at a higher point by an incision continuous with the original wound, the fresh raw surface will inevitably be infected from the foul wound. Against this it may be urged that it is very possible that the fresh incision, even if made at a distance, may become infected with the unhealthy process affecting the original wound, especially in cases of erysipelas, hospital gangrene, or wound diphtheria, and thus nothing would be gained by applying a ligature at a distance on the proximal side. Moreover, when the wound is freely opened up it may, in most cases, be brought into a healthy condition by the free application of some powerful antiseptic, such as chloride of zinc (gr. 40 to ℥j.), or perchloride of mercury (1 in 500), and afterwards dusting the surface with iodoform, and applying some antiseptic dressing.

For these reasons it may be stated as a general rule, to which there are but few exceptions, that however deep the wound, and however unhealthy the neighbouring parts may be, there is no safety to the patient unless the artery be exposed and tied at the part injured. An operation of this kind is often attended with the greatest difficulty, not only owing to the hæmorrhage that usually accompanies it and obscures the parts, but also in consequence of the inflamed, infiltrated, and sloughy condition of the tissues in the wound. In applying the ligature under these circumstances, the tissues will necessarily have in a great degree lost their cohesion and firmness; and although the arterial coats resist the disorganising influence of inflammation much longer than areolar or muscular tissue, yet they will also have become softened and less resistant. Hence the vessel must be isolated with gentleness, and the ligature very carefully applied. In many cases it will be necessary to expose the artery a short distance from the surface of the wound in order to find a part sufficiently healthy to hold the ligature.

The *exceptions to this rule* are in the first place the same as in primary hæmorrhage, viz., the deep branches of the carotid and some cases of wound

of the deep palmar arch. Secondly, in extremely foul or sloughing wounds, the Surgeon may fail to secure the bleeding point by ligature or other means, and under these circumstances proximal ligature is his only resource. Thirdly, if the bleeding has recurred more than once after ligature in the wound the Surgeon may, as a last chance, apply a ligature to the main trunk at a distant point.

In applying these rules it must be considered whether the bleeding takes place, 1, from a stump; or, 2, from an artery tied in its continuity or ligatured on each side of a wound.

1. The treatment of **secondary hæmorrhage from a stump** will depend partly on the degree of union that has taken place between the flaps, and on the situation of the stump. If the hæmorrhage be no more than a slight oozing, elevation and pressure may arrest it. Should it continue, however, the Surgeon has three courses open to him: separation of the flaps and ligature of the artery at the bleeding point; ligature of the main artery above the stump; and, lastly, re-amputation. The first of these alternatives, viz., *ligature of the artery at the bleeding point*, is universally recognised as the object to be aimed at if the hæmorrhage have occurred early when the flaps are still easily separated, or in later cases when the union has been extensively broken down by the hæmorrhage. But even if, notwithstanding the hæmorrhage, the union between the flap continues sound and firm, the blood flowing merely through a narrow channel leading to the main vessel, this same rule must, in most cases, be followed. The wound must be opened up, all adhesions, however firm, being broken down with the finger, and the artery must be secured at the bleeding point. Besides the main artery that bleeds—one of the tibials, for instance, if it be a leg-amputation—there will generally be very free oozing from many points. The more abundant of these may be stopped by a ligature passed, if the tissues be friable, by means of a nævus-needle under the vessels; free general oozing may usually be arrested by clearing the surfaces of the flaps of all coagula, and by the firm uniform pressure of the dressing.

If the tissues are so softened that ligatures will not hold, the actual cautery may be applied to the smaller bleeding points, whilst in the case of the main artery a sufficiently healthy part of the vessel may be reached by separating it for a short distance from the face of the flap. The treatment of secondary hæmorrhage from the main artery by digital compression of the vessel higher in the limb or the use of a horse-shoe tourniquet is too uncertain to be recommended.

In those cases where the amputation has been done close to the trunk, as at the shoulder-joint or the middle or upper part of the thigh, there is less objection to the practice of ligaturing the artery at a higher level instead of opening up the stump. The length of limb to be nourished is so small that there is little fear of gangrene. Even in these cases, however, the Surgeon will be wise to follow the general principle of treatment, and by opening up to a sufficient extent the track from which the blood is escaping, to endeavour to apply a ligature above the bleeding point.

Ligature of the main artery above the stump is the only alternative in those amputations close to the trunk in which the hæmorrhage recurs after an attempt has been made to arrest it by opening up the flaps. In the case of the shoulder the third part of the subclavian should be tied, and in amputa-

tions in the upper part of the thigh a ligature should be applied to the common femoral or the external iliac just above Poupart's ligament. Ligature of the artery at a higher level must also be tried under similar circumstances in all amputations in the upper limb and in amputations in the lower part of the thigh. In such cases, also after amputation of the foot, I have successfully tied the posterior tibial just above the malleolus. Should this not succeed in arresting the bleeding, or be followed by gangrene, *reamputation* is the last resource.

In the case of secondary hæmorrhage from a leg stump below the knee in which the first method of treatment has failed, no good is likely to follow the application of a ligature to the femoral. This either fails to arrest the bleeding or produces gangrene, and thus necessitates reamputation at a higher level than would otherwise be necessary.

2. When the hæmorrhage occurs after ligature of an **Artery in its Continuity**, whether for injury or disease, if the vessel be situated in the *trunk*, as the subclavian, or one of the iliacs, there is nothing to be done but to apply pressure ; and in the great majority of these cases the patient will die exhausted by repeated hæmorrhage. In employing pressure a graduated compress should be firmly applied. If this cannot be done, prolonged digital compression in the wound might possibly arrest the bleeding. In a case of ligature of the innominate, Smythe, of New Orleans, arrested the bleeding by pushing a piece of muslin into the wound and filling the pouch thus formed with shot.

When the artery is situated in one of the limbs, if the bleeding has been very slight in amount, pressure may be applied over the point from which the blood proceeds, but if the bleeding has been copious, and more especially if pressure has failed after one trial, more efficient procedures must be employed.

If it be one of the arteries of the *upper extremity* the wound should be opened up and an attempt made to expose the vessel thoroughly. If it has been completely divided by the ligature, the bleeding end only need be tied, but if the hæmorrhage proceeds from an opening formed by ulceration opposite the knot of the ligature, the vessel should be tied above and below the hole in its coats. Should this fail or not be practicable, the artery must be deligated at a higher point than that at which it had previously been tied ; should the hæmorrhage continue, or recur, amputation is the only resource left.

In the *lower extremity*, the treatment of secondary hæmorrhage occurring after ligature is surrounded with difficulty. Here I believe it to be useless to tie the artery at a higher point than that to which the ligature has already been applied, as gangrene is very apt to follow this double ligature : at least, in the two or three cases that I have seen in which recourse has been had to this practice, and in all the reported cases with which I am acquainted, mortification of the limb has ensued. The treatment should vary according as we have the femoral artery or one of the tibials to deal with. If the hæmorrhage proceed from the femoral, I should be disposed to cut down on the bleeding part of the vessel, treating it as a wounded artery, and applying a ligature above and below the part already deligated ; this operation would, however, necessarily be attended with difficulty. Should it be impracticable, or should the hæmorrhage recur after it has been done, we should best consult the safety

of the patient by amputating on a level with or above the ligature. Although this is an extreme measure, it is infinitely preferable to allowing him to run the risk of the supervention of gangrene, which will require removal of the limb under less favourable conditions. If the secondary hæmorrhage proceed from one of the tibials, it would be all but useless to adopt either of the preceding alternatives. If we ligatured the superficial femoral, the bleeding would not be permanently controlled, or, if it were, gangrene of the limb would in all probability set in. There are very few cases on record in which this practice has been adopted without mortification occurring. In a few rare instances, however, ligature of the popliteal has, in such circumstances, succeeded; but it has also frequently failed, rendering secondary amputation necessary; so its success is a mere matter of chance. The depth at which the tibials are situated is so great, that it would be hopeless to search for one of these vessels and attempt its deligation at the bottom of a deep, sloughy, infiltrated and inflamed wound. In such circumstances, therefore, I think we should amputate the leg above the seat of wound. This is truly a severe measure; but the only alternative that has, to my knowledge, ever succeeded, is ligature of the popliteal; and as that, as already stated, has frequently failed, I think that, as a rule, we should best consult the safety of the patient by the removal of the limb at once.

If the hæmorrhage occur from a wounded artery to which ligatures have already been applied above and below the seat of the wound, the same treatment must be adopted as in those cases in which the bleeding takes place from a vessel tied in its continuity.

Hæmorrhage from arteries opened by ulceration or sloughing must be treated on the same principles as in other forms of secondary hæmorrhage. If the loss of blood has been abundant we must not wait for a recurrence of the hæmorrhage before seeking for the bleeding point, and the ligature should, if possible, be applied above and below the opening in the artery; proximal ligature at a distance being justifiable only when this is impossible, or an attempt to carry it out has failed.

GANGRENE FOLLOWING LIGATURE.—After the ligature of the main artery of a limb, the collateral circulation is, under all ordinary circumstances, sufficient to maintain the vitality of the parts supplied by the deligated vessel. In some cases, however, it happens that the condition of the circulation in the parts below the ligature is not compatible with their life.

The *Period of Supervention* of gangrene of the limb extends over the first three or four weeks after the ligature of the vessel. It seldom sets in before the third day, but most frequently happens before the tenth.

Causes.—The causes influencing the occurrence of gangrene in this way are the Age of the Patient, the Seat of the Operation, and various Conditions in which the limb may afterwards be placed.

The influence of *age* is not, however, so marked as might *a priori* be supposed; for, although there can be no doubt that there is less accommodating power in the arterial system at an advanced period of life to varying quantities of blood, and that there would be greater difficulty in maintaining the vitality of a limb after ligature of its artery in a man of sixty than in one of twenty-five, yet I find that, of thirty cases in which gangrene of the lower extremity followed the ligature either of the external iliac or femoral arteries, the average age of the patient was thirty-five years, as nearly as

possible the mean age at which these operations, according to Norris's Tables, are generally performed. Of these cases of gangrene two occurred in persons under twenty years of age, eleven between twenty and thirty, eight between thirty and forty, and nine above forty.

The *seat of the operation* influences greatly the liability to gangrene, which is much more frequent after the ligature of the arteries in the lower than in the upper extremity.

Besides these predisposing causes, gangrene after ligature may be directly occasioned by a *deficient supply of arterial blood*. In some cases this may arise from the collateral vessels being unable, in consequence of the rigidity of their coats, to accommodate themselves to the increased quantity of blood which they are required to transmit; or they may be compressed in such a way by extravasation as to be materially lessened in their capacity. In other instances again, the existence of cardiac disease may interfere with the proper supply of blood to the part.

Great *loss of blood*, either in consequence of secondary hæmorrhage, or from any other cause, before or after the application of the ligature, is often followed by gangrene, and is almost certain to be attended by this result if a second ligature have been applied to a higher point in the lower extremity. That a diminution in the quantity of blood circulating in the system may, under the most favourable circumstances, become a cause of gangrene after the ligature of a main artery, is illustrated by the statement of Hodgson that, soon after the introduction of the Hunterian operation into Paris, it was the custom to employ repeated venesection in the cases operated on; the consequence of which was, that mortification was of frequent occurrence.

A more common cause of gangrene is the *difficulty experienced by the venous blood in its return from the limb.* This difficulty always exists even when no mechanical obstacle impedes the return, being dependent on the want of a proper *vis a tergo* to drive on the blood. The propulsive force of the heart, the main agent in the venous circulation, is largely expended in driving the blood through the narrow and circuitous channels of the anastomosing vessels. This difficulty to the onward passage of the venous blood may, if there exist any cause of obstruction in the larger venous trunks, be readily increased to such an extent as to arrest the circulation, and so cause the limb to mortify. This mechanical obstacle may be dependent upon the occlusion of the vein by thrombosis opposite the ligature, by its transfixion with the aneurism-needle, or by its accidental wound with the knife in exposing the artery. When such an injury, followed by inflammation, is inflicted on a vein, which, like the femoral, returns the great mass of blood from a limb, gangrene is almost inevitable.

The supervention of *erysipelas* in the limb after the application of a ligature, though fortunately of very infrequent occurrence, is a source of considerable danger, being very apt to give rise to gangrene by the tension of the parts obstructing the anastomosing circulation. I have on two occasions seen gangrene of the fingers, from this cause, follow ligature of the vessels of the forearm.

Abstraction of heat from the limb, either directly by the application of cold, or indirectly by the neglect of sufficient precautions to keep up the temperature of the part, often occasions gangrene; thus, Astley Cooper saw mortification follow the application of cold lead lotion to a limb in which the femoral artery

had been tied; and Hodgson witnessed the same result when the operation was performed at an inclement season of the year.

The *incautious application of heat* may occasion mortification, by over-stimulating the returning circulation of the limb, especially about the period when the rising temperature indicates distension of the capillary vessels. In this way the application of hot bricks and bottles to the feet has given rise to sloughing; and Liston was compelled to amputate the thigh after ligature of the femoral artery, for gangrene induced by fomenting the limb with hot water.

The *application of a bandage*, even though very cautiously made, is apt to induce gangrene. I have seen this happen when a roller was applied to the leg after ligature of the femoral artery, with the view of removing œdema.

Character.—The gangrene from ligature of an artery is almost invariably of the moist kind, as it usually arises from diminished *vis a tergo* and consequent stagnation of blood. The limb first becomes œdematous; vesications then form; and the skin assumes a purplish or greenish-black tint, rapidly extending up to the seat of operation. In some cases, though they are rare, simple mummification of the limb comes on; the skin assuming a dull yellowish-white hue, mottled by streaks that correspond to the veins, and becoming dry, horny, and shrivelled, about the extensor tendons of the instep.

Treatment.—Much may be done with the view of preventing gangrene. Thus, the limb should be slightly elevated, wrapped up loosely in cotton-wadding, and laid on its outer side after the operation. If the weather be cold, hot-water bottles may be put into the bed, but *not in contact with the limb.* Should there be any appearance of stagnation of venous blood, the plan recommended by Guthrie of employing continuous and methodical friction in a direction upwards for twenty-four hours, so as to keep the superficial veins emptied, may be practised.

When mortification has fairly set in, amputation of the limb should be performed at once as the only chance of saving life, in all those cases in which the patient's constitutional powers are sufficiently strong to enable him to bear the shock of the operation. The limb should be removed at the seat of the original wound, or opposite the point at which the artery has been tied. In those cases, however, in which the gangrene follows injury of the femoral artery just below Poupart's ligament, Guthrie advises that the amputation should be done below the knee, where the gangrene usually stops. If the gangrene spread, with œdema or serous infiltration of the limb, the amputation should be done high up—at the shoulder-joint, or in the upper third of the thigh. In these cases a large number of vessels usually require ligature, having been enlarged by the collateral circulation.

CHAPTER XV.

TRAUMATIC ANEURISM AND ARTERIO-VENOUS WOUNDS.

TRAUMATIC ANEURISM.

We have hitherto discussed those wounds of arteries in which the blood is discharged freely from an open wound, but all cases are not so simple as these. It sometimes happens that there is a subcutaneous extravasation, forming a more or less distinct cavity, into which the blood is thrown from the wounded artery, accompanied usually by pulsation of the swelling, and occasionally by thrill and bruit. This extravasation constitutes a **Traumatic Aneurism**, and may arise in three ways: 1, The punctured wound leading to the injured artery may be oblique or indirect, and thus the blood may partly escape at the cutaneous opening, and partly be extravasated into the tissues around the vessel. 2, The puncture in the integuments may be closed by plaster, or a pad of lint and a bandage, and thus no blood may escape externally, although the wound in the artery remains patent, and blood is forced out into the substance of the part. 3, There may be no external wound, the artery being punctured or torn subcutaneously by the fragments of a fractured bone, by a violent strain, by the injury inflicted in a dislocation, or by the Surgeon in his efforts to reduce it.

Two forms of aneurism are described as arising from such injuries as the above: the diffused and the circumscribed.

Diffused Traumatic Aneurism.—This consists of an effusion of blood from a wounded or ruptured artery, limited in extent by the resistance of the surrounding parts. In the immediate neighbourhood of the opening in the vessel there is an ill-defined cavity communicating with the artery formed by the separation of the surrounding parts by the pressure of the blood. There is no true sac, and such boundary as there may be is formed partly by coagulum, and partly by the surrounding fasciæ, muscles and other structures more or less matted together by inflammatory exudation. The extravasation continues to increase and to force its way amongst the tissues of the part until the resistance offered by the stretched and distended structures is equal to the pressure in the injured artery.

The effects of subcutaneous arterial hæmorrhage necessarily vary with the size of the artery, the nature of the wound, and the laxity of the surrounding parts. Thus, if the axillary artery be lacerated in the attempted reduction of an old dislocation of the shoulder-joint, the axilla, the loose tissue beneath the pectoral muscles and in the root of the neck, may be tensely distended with extravasated blood in a few minutes, while in a punctured wound of a deep-seated smaller vessel, such as the posterior tibial, many hours or even days may elapse before the extreme limit of distension of the surrounding parts has been reached. Many Surgeons, with much reason, object to the use of the word "aneurism" in connection with the more rapid arterial extravasations,

and no doubt such cases had better be described as "subcutaneous arterial hæmorrhages," but no sharp line can be drawn between them and the less perfectly circumscribed traumatic aneurisms.

Subcutaneous arterial hæmorrhage is indicated by the formation of a soft semi-fluctuating tumour often of very considerable size. If the opening be free and in a large artery the swelling increases rapidly, accompanied by the most intense tearing and throbbing pain, which may be at once relieved by pressure on the main trunk leading to the injured part. With this, in extreme cases, there may be the constitutional symptoms of loss of blood (p. 409). At first the skin covering the part is of natural colour, but as the pressure increases it may become congested and dusky. If the vessel be large there will at first be distinct pulsation in the tumour occasionally accompanied by a thrill and a distinct bruit, but these signs as a rule disappear as the tension of the distended parts becomes greater and the extravasated blood begins to coagulate. For this reason, unless the case is seen very early the diagnosis is often extremely difficult. If the hæmorrhage be from a small vessel or from a small punctured wound of a large vessel, and the surrounding parts be not lax, the swelling caused by the extravasation, after reaching a certain size somewhat rapidly, will increase more slowly so that some days may pass before a high degree of tension is developed. In whatever way arising, as soon as the tension becomes marked the pressure of the extravasated blood arrests the return of blood through the veins accompanying the artery, and in this way great œdema of the parts below the injury may be caused. Before much extravasation has taken place pulsation may be felt in the artery below the seat of injury unless the vessel be completely torn across or extensively injured, but most commonly this ceases when the pressure from extravasation becomes great. As soon as the extravasation reaches a sufficient size the tension it exerts on the surrounding tissues gives rise to all the phenomena of inflammation. The skin covering the swelling becomes hot, red, and œdematous. The red colour is often modified by the pigment from the extravasated red corpuscles, the various tints commonly seen in a bruise being mingled with the florid red of acute inflammation. Tenderness and acute throbbing pain are also present, and the temperature may rise to three or four degrees above the normal point; thus this condition may very closely resemble an acute abscess, and many cases are on record in which an incision has been made into the tumour under this supposition.

These cases if left alone rarely, if ever, undergo spontaneous cure. They either increase in size until the integument covering them sloughs and ruptures, or the external wound, which has been temporarily closed, gives way; or else they inflame and suppurate, pointing at last, like an abscess, and, on bursting, give rise to a sudden gush of blood, which may at once, or by its rapid recurrence, prove fatal. The combined obstruction to the flow through the artery and the pressure on the veins may cause gangrene of the limb at an early stage of the case. In some cases the temporary boundary of clotted blood and inflammatory exudation may give way, and the loss of blood extravasated into the areolar tissue beneath the fascia of the limb may be so great as to cause death from syncope.

Diagnosis.—Large subcutaneous arterial hæmorrhages, if seen early, are usually recognised without difficulty. The nature of the injury, the rapid swelling, possibly pulsating at first, the great tension and pain, the cessation

to allow of the temporary arrest of the bleeding by digital pressure below the carotid tubercle, this should be at once done. The wound must then be enlarged, and if possible, the artery tied above and below the bleeding point, parts of one or more of the transverse processes being removed, if necessary. Failing this, the Surgeon must resort to careful plugging of the wound, or he may be able to seize the bleeding vessel in forcipressure-forceps and leave them *in situ* for several days.

Traumatic Aneurism of the Vertebral Artery has been recorded in twenty cases by Matas, of which six recovered, one of these being a case of his own, in which the sac was freely laid open in the suboccipital region and the hæmorrhage successively arrested by plugging. This treatment would appear to give the best hope of success, if digital compression of the artery and direct pressure on the aneurism fail to produce a cure.

VESSELS OF THE TRUNK.

INTERNAL MAMMARY.—Wounds of this artery rarely come under treatment, as its course lies chiefly in front of the heart and great vessels, so that penetrating wounds implicating it are usually immediately fatal from injury to the parts beneath. The *treatment*, in case the patient escapes fatal injuries to deeper parts, is to tie the artery at the wounded spot, if necessary removing a costal cartilage in order to expose it. No other treatment is likely to arrest the bleeding, because of the free anastomoses with the intercostals.

INTERCOSTAL ARTERIES.—These are rarely wounded except in gunshot wounds or stabs fracturing a rib. The hæmorrhage is seldom severe; but should it require *treatment*, the lower border of the rib corresponding to the artery must be exposed by a free incision. On removing the fragments the bleeding artery may come into view, and can be twisted or tied; or it may be turned out of its groove by means of a periosteal elevator, and sufficiently exposed to be tied. If necessary, a piece of rib may be removed to lay bare the vessel more fully. As a temporary means, pressure can be applied thus:—A piece of linen is to be pushed through the wound into the pleural cavity, so as to form a pocket; inside a sufficient quantity of lint or tow is pushed into the pocket to make it too large to pass out by the intercostal space; it is then forcibly pulled upon by the part of the linen outside the chest-walls, and secured in position by a couple of pins pushed across on a level with the skin.

VESSELS OF THE UPPER LIMB.

SUBCLAVIAN ARTERY.—**Wounds of the Subclavian Artery** are almost invariably fatal; though, owing to the protection afforded by the clavicle, they rarely occur except from gunshot injuries or stabs. From the rapidly fatal nature of wounds of the subclavian artery, **Traumatic Aneurisms** in this situation are not met with; but where the artery passes into the axilla below the margin of the first rib, they are not unfrequent.

Aneurismal Varix, resulting from wound of the *Subclavian Artery and* ... has been seen, notwithstanding the separation that exists between the ...essels throughout their whole extent. These injuries have likewise been the result of sword-thrusts, and do not admit of any surgical ...e.

AXILLARY ARTERY.—In **Open Wounds of the Axillary Artery and its Branches**, the rule of practice is to expose the bleeding vessel and tie it on each side of the wound. The branches of the artery are so numerous that there must always be some uncertainty, in a case of punctured wound, whether the main trunk or a branch is injured, even when the direction of the wound and the abundance of the bleeding would suggest the former. This doubt can be cleared up only by exposing the bleeding point, and in order to do this efficiently, it may sometimes be necessary to divide both the pectoral muscles across the line of their fibres.

In secondary hæmorrhage, the state of the parts may be such as to make it very difficult to expose the artery cleanly in the wound, and the temptation to apply a proximal ligature under these circumstances is very strong, but this should never be done before a thorough attempt has been made to tie the vessel at the bleeding point, by freely opening up the wound and enlarging it, if necessary. The anastomoses between the branches of the subclavian and the axillary are so free that ligature of the third part of the subclavian is extremely likely to fail. Ligature of the first part of the axillary artery would, in a case of secondary hæmorrhage, be just as difficult as exposing the bleeding point, and could be done after division of the pectoralis major and minor, should it be impossible to secure the vessel at the wounded point. In a case of secondary hæmorrhage, the ligature of the first part of the axillary by a curved incision below the clavicle, as described in Chap. XLIV., Vol. II., would be most difficult; as the axilla would probably be filled with extravasated blood, and the parts matted together by the inflammation and suppuration which caused the failure in the repair of the artery. In all cases of secondary hæmorrhage, it would be safer to expose the artery by an incision in the line of the vessel dividing the pectoral muscles. The subclavian must be tied above the clavicle only as a last resource. The operation has been attended with success enough to justify its adoption should other means fail. Of 15 cases in which it has been performed for hæmorrhage from wounds in the axilla or from stumps, I find that 9 were cured and 6 died.

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There are more than 40 cases on record in which axillary aneurism has followed an injury to the vessel occurring during the reduction of a dislocation. In only a few of these has the dislocation been recent. Amongst these is one recorded by Warren in which the vessel was ruptured in consequence of the Surgeon using his foot in the axilla as a fulcrum, but without taking off his boot. In the great majority of cases the dislocation has been of old-standing, and considerable force has been used. Gibson has related three cases of rupture of the artery in the attempt to reduce such cases by the pulleys. Pelletan mentions a case in which the rapid swelling following the rupture of the artery was mistaken for emphysema from fractured ribs. An incision was made into it and the patient bled to death. These cases show the necessity for great caution in the use of powerful extending force in the reduction of old dislocations, when adhesions may have formed between the artery and the head of the bone.

Distinction must be clearly made between the diffused and circumscribed forms of traumatic aneurism of the axilla. In the *diffused variety* there is subcutaneous arterial extravasation, forming more or less rapidly a tumour of considerable size. The swelling presents none of the characteristic signs of an aneurism, and can be distinguished from an ordinary extravasation by the loss of the pulse at the wrist and the œdema of the arm. Some of these arterial extravasations in the axilla tend to diffuse themselves with great rapidity, extending under the pectoral muscles, and even up around the shoulder.

In all these cases there is great danger of suppuration and sloughing of the tissues into which the blood is extravasated, and gangrene of the limb itself may result.

In the *circumscribed form*, on the other hand, the swelling developes slowly, and presents the usual signs of aneurism, such as thrill and pulsation. Under these circumstances the disease may get well spontaneously, as happened in cases recorded by Van Swieten, Sabatier, and Hodgson. In other instances again, the disease has remained stationary for years, or has undergone consolidation under medical treatment. It cannot, however, be considered sound practice to leave a circumscribed traumatic aneurism of this artery without surgical interference, after the ordinary dietetic and hygienic plans of treatment have failed, for it may at any time become rapidly diffused, or inflame and suppurate.

The *Treatment* of traumatic axillary aneurism must depend on whether it be diffused or circumscribed.

In *subcutaneous arterial extravasation*—the so-called diffused traumatic aneurism—the plan of treatment recommended so strongly by Guthrie must always be followed, viz., to open up the axilla, turn out the coagula, and ligature the wounded artery. The treatment is the same whether the extravasation result from a punctured wound or a subcutaneous rupture of the vessel. The operation consists in compressing the subclavian above the clavicle, either by the pressure of the finger from the surface, or, as was done by Syme in his case, by previously making an incision over it, through which it could be more readily commanded; then laying the tumour open by a free incision through the anterior fold of the axilla and the pectoral muscles, turning out the coagula, and seeking for and ligaturing both ends of the artery; for it must be remembered that the distal extremity of the torn vessel will probably bleed freely, owing to the open anastomoses round the shoulder.

Should secondary hæmorrhage or gangrene follow the operation, amputation at the shoulder is the only plan that holds out a chance of life to the patient. The result of departing from this first principle of the treatment of diffused traumatic aneurism is well shown by three recorded cases in which the subclavian artery was tied for extravasation following subcutaneous rupture of the axillary artery. Two of the patients died of gangrene and secondary hæmorrhage, and in the successful case, secondary hæmorrhage occurred, gangrene of the arm threatened, and life was saved only by amputation at the shoulder-joint.

In the treatment of the *circumscribed variety* the same principle cannot guide us as in the management of the diffuse extravasation, for not only is the circumscribed aneurism provided with a sac, but the vessel at the point injured will very probably be found to have undergone changes that render it little able to bear the application of the ligature. It will be softened, thickened,

and lacerable, with perhaps a wide funnel-shaped aperture leading into the sac, which will be closely incorporated with the neighbouring parts. But, indeed, the treatment of this form of circumscribed traumatic aneurism by the ligature of the artery on the proximal side of the sac has been found to be attended with remarkable success. In eight recorded cases in which this operation was performed, not one fatal result was noted. In all, the aneurism arose from stabs or gunshot wounds, and had existed for various periods, ranging from two weeks to four years. In four of the cases the artery was ligatured above, and in four below the clavicle: and in one case of each category there was suppuration of the sac.

The particular point at which the artery should be ligatured must depend upon the condition of the tumour. If this be of large size, or arise from the upper part of the axillary artery above or immediately below the pectoralis minor muscle, there is no choice but to deligate the vessel above the clavicle. Should, however, the principal increase in the tumour take place in a direction downwards and forwards under the great pectoral muscle, the portion of the artery immediately below the clavicle not being covered by the sac, the question would arise whether this part might not be selected for the application of the ligature; and as the results of both operations have hitherto been equally favourable, this must rather be determined by the peculiarities in each case than on more general grounds. Most Surgeons, I think, would prefer ligaturing the artery above the clavicle, as being a simpler proceeding than tying it below that bone; the latter procedure, moreover, has the disadvantage of bringing the scalpel into very close proximity with the sac, which, were it to stretch upwards under the pectoralis minor to a greater extent than could be discernible externally, might possibly be opened by the knife, as has happened even in operating above the clavicle.

Compression of the artery on the distal side of the tumour succeeded in curing the disease in a case that was under Goldsmith of Vermont.

Brachial Artery.—The hæmorrhage from **Wounds of the Brachial Artery** should be arrested by ligature on each side of the aperture.

This vessel may be punctured in venesection, an accident which was formerly of frequent occurrence when blood-letting was practised by professed phlebotomists; an abundant escape of blood will then occur while the thumb is still on the vein. Should the condition of the patient permit, and the necessary instruments and assistance be at hand, the Surgeon should expose the artery and apply a ligature above and below the wound, at the same time tying the wounded vein. Frequently, however, this treatment will be impracticable, and all that can be done will be to apply a graduated compress. If the patient recover from the disease for which he was bled and an aneurism form, it may be operated on at a later time.

In the **Circumscribed Traumatic Aneurism** at the bend of the arm, following a wound of the brachial artery, we have the usual soft or semi-solid pulsating tumour, which can readily be emptied by pressure, and is accompanied by more or less bruit. This disease may be *treated* in one of three ways: 1, by compression upon or above the tumour; 2, by ligaturing the artery leading to it; or 3, by cutting through the sac, and deligating the vessel on each side of the aperture in it.

Compression has been successfully carried out by means of a graduated compress on the tumour, and a ring-tourniquet on the artery higher up.

traumatic aneurism, communicating on one side with the artery, and on the other with the vein, which is always in a state of varix. A varicose aneurism is, in fact, a circumscribed traumatic aneurism *plus* an aneurismal varix. This is well represented in the annexed cuts, from drawings of Sir C. Bell's, in the museum of University College, representing a varicose aneurism before and after it had been opened (Figs. 151 to 154). In this case there appears to have been a high division of the brachial, and a communicating branch below the wound, between the radial and ulnar; in consequence of which, as

Fig. 153.—The same Tumour laid open, showing the Circumscribed False Aneurism between the two Vessels.

Mr. Shaw informed me, the tumour pulsated as forcibly after the artery had been tied as before, the blood finding its way back through the aneurism into the veins. Gangrene of the hand and arm followed.

Symptoms.—In the symptoms of varicose aneurism, we have a combination of the characters of aneurismal varix and of the circumscribed traumatic aneurism; there is a pulsating tumour, at first soft and compressible, but, after a time, becoming more solid, in consequence of the deposit of fibrin within it: superficial to this tumour, the vein is dilated into a fusiform pouch.

Fig. 154.—The opened Tumour removed from its Connections.

presenting the ordinary characters of varix. The sounds heard in these tumours are of two distinct kinds: there is the peculiar buzzing thrill that always exists where there is a communication between an artery and a vein: besides this there is a blowing or bellows sound, caused by the aneurism. These signs are most perceptible when the limb is in a dependent position; and the sounds can often be heard in the veins at a considerable distance from the seat of injury. There is also some impairment in the nutrition and temperature of the parts supplied by the injured vessels. As the disease advances,

the vein is due to abnormal blood-pressure from the direct entry of arterial blood into it.

The **Symptoms** consist of a tumour at the seat of injury, which can be emptied by pressure upon the artery leading to it, or by compressing its walls. If subcutaneous, this tumour is of a blue or purple colour, of an oblong shape, and will be seen to receive the dilated and tortuous veins. It will be found to pulsate distinctly with a tremulous jarring motion, rather than a distinct impulse. Auscultation detects in it a loud and blowing, whiffing, rasping, or hissing sound, usually of a peculiarly harsh character. This sound has very

Fig. 151.—A Varicose Aneurism at the Bend of the Arm unopened.

aptly been compared by Porter to the noise made by a fly in a paper-bag, and by Liston to the sound of distant and complicated machinery. The thrill and sound are more distinct in the upper than in the lower part of the limb, and are most perceptible if the limb be allowed to hang down so as to become congested. Besides these local symptoms, there is usually some muscular weakness, together with diminution in the temperature of the part supplied by the injured artery.

Treatment.—As this condition, when once established, is stationary, all

Fig. 152.—The same Varicose Aneurism removed from its connections.

operative interference should be avoided, an elastic bandage merely being applied. Should a case occur in which more than this is required, the artery must be cut down upon and ligatured on each side of the wound in it. Holmes suggests that in aneurismal varix a cure might possibly be obtained by pressure directed solely to the orifice in the vein.

Varicose Aneurism.—In this condition the openings in the artery and vein do not directly communicate (see Figs. 152 and 153), but an aneurismal sac is formed between the two vessels, through which the blood passes into the vein.

The **Pathological Condition** consists in the formation of a circumscribed

CHAPTER XVI.

WOUNDS OF SPECIAL BLOOD-VESSELS.*

VESSELS OF THE HEAD AND NECK.

Carotid Artery.—**Wounds of the Carotid Artery** and of its branches are not uncommon in civil practice, as the neck is frequently the seat of suicidal wounds. The hæmorrhage from wounds of the main trunk is usually immediately fatal. In the event of a Surgeon being at hand, both ends of the bleeding vessel must be ligatured. Should the jugular vein be also wounded a ligature must be applied above and below the opening, but if the wound be very small—a mere puncture—it may be closed by pinching it up and applying the ligature in such a way as not completely to occlude the vessel. Should the hæmorrhage, whether primary or secondary, proceed from a deep branch of the external carotid, as the internal maxillary, so situated as not to admit of the vessel being ligatured at the seat of wound, the ordinary rule of tying a wounded artery at the seat of injury must be departed from, and the main trunk must be ligatured at the most convenient spot. Considerable difference of opinion has existed as to whether, under these circumstances, it is better to tie the external or the common carotid. Guthrie strongly advocated the application of the ligature to the external carotid, but most Surgeons have preferred to tie the common trunk above the omo-hyoid, fearing that the application of a ligature amongst the numerous branches of the external carotid would be followed by secondary hæmorrhage. The results of this mode of treatment, however, have been far from satisfactory; not only have many patients died directly from the operation itself, but in a very large proportion the hæmorrhage for which it was performed has recurred and proved fatal. Harrison Cripps has collected 50 cases of ligature of the common trunk for hæmorrhage, 28 of which terminated fatally. He has therefore advocated a return to Guthrie's practice of applying the ligature to the external carotid, and the exact point he recommends is *between the superior thyroid and the lingual*. Wyeth recommends simultaneous ligature of the superior thyroid. This operation is not difficult of performance, and seems in itself to be less dangerous than the deligation of the main trunk. Madelung has collected the records of 60 cases, of which only 7 died. There seems every reason therefore for preferring it, when possible, to the more serious operation of tying the common trunk.

Internal Carotid.—If the internal carotid is wounded, ligature of the common carotid gives the best chance of recovery.

In consequence of the speedy fatality of the wounds of the carotid artery and its branches, **Traumatic Aneurisms** are rarely met with in this situation; they do, however, occasionally occur, and the records of surgery contain

* A full description of the operations required for the ligature of the various arteries will be found in Vol. II., Chapters XLIII. and XLIV.

at least six instances of the kind, in each of which the common carotid was tied, and the patient ultimately recovered.

Aneurismal Varix in the Neck, dependent on puncture of the **Internal Jugular Vein and Carotid Artery,** usually the result of sword-thrusts, is apparently of more frequent occurrence than traumatic aneurism in this region: probably owing to the close proximity of the vein rendering it difficult for the artery to be wounded on the outer or anterior sides, without that vessel being first perforated. The symptoms offer the general characteristics of aneurismal varix, but have several points that are worthy of special remark.

The wound of the vessels has been in every instance followed by the effusion of a large quantity of blood into the loose areolar tissue of the neck; the extravasation acquiring even the size of a child's head, and threatening immediate suffocation. As this extravasation subsided, the ordinary characters of aneurismal varix began to manifest themselves. The period at which these symptoms first made their appearance varied somewhat in the different cases, but they always occurred within four or five days of the receipt of the injury. In none of the cases did the disease appear to shorten life, or to occasion any dangerous or inconvenient effects, with the exception of some difficulty in lying on the affected side, and occasional giddiness or noise in the head on stooping. No operation is admissible in these affections.

Varicose Aneurism of the internal jugular and carotid artery is rare. Playette has collected 16 cases, all of which tended to amelioration or spontaneous cure. Three cases were operated upon; two of these died, and the third was not improved.

Temporal Artery.—**Traumatic Aneurism of the Temporal Artery,** and of its branches, has occasionally occurred as the result of partial division of these vessels in cupping on the temple. I have met with two cases of this kind, in both of which the disease was readily cured by laying the tumour open, turning out its contents, and tying the artery on each side of it.

Internal Maxillary.—This artery is occasionally injured and wounded in gunshot wounds. If the hæmorrhage be too copious to be restrained by hot water, cold or styptics, the external or common carotid must be tied.

Lingual Artery.—This vessel is occasionally injured in gunshot wounds. If the bleeding point cannot be seized by forcipressure-forceps from the mouth and the Surgeon can be perfectly certain that the blood is coming from the lingual, he may tie that vessel above the hyoid bone (see Diseases of the Tongue), otherwise it is better to ligature the external or common carotid—the external for choice.

Vertebral Artery.—**Wounds of the Vertebral Artery** occasionally occur as the result of stabs or gunshot wounds in the neck. In these wounds there is a danger of mistaking the source of the hæmorrhage, as pressure on the carotid, if made below the transverse process of the sixth cervical vertebra, arrests the flow of blood in the vertebral as well, which, up to this point, lies immediately beneath it. This transverse process is at least two inches above the clavicle, and lies much higher than one is apt to think. There are no fewer than sixteen cases on record in which the carotid has been tied for a wound of the vertebral, in consequence of this mistake. Of nineteen cases of wound of the vertebral collected by Matas, only two recovered, and in both the hæmorrhage was arrested by plugging the wound, the plugs in one case being dipped in a styptic solution. If the wound of the vessel be sufficiently high

to allow of the temporary arrest of the bleeding by digital pressure below the carotid tubercle, this should be at once done. The wound must then be enlarged, and if possible, the artery tied above and below the bleeding point, parts of one or more of the transverse processes being removed, if necessary. Failing this, the Surgeon must resort to careful plugging of the wound, or he may be able to seize the bleeding vessel in forcipressure-forceps and leave them *in situ* for several days.

Traumatic Aneurism of the Vertebral Artery has been recorded in twenty cases by Matas, of which six recovered, one of these being a case of his own, in which the sac was freely laid open in the suboccipital region and the hæmorrhage successively arrested by plugging. This treatment would appear to give the best hope of success, if digital compression of the artery and direct pressure on the aneurism fail to produce a cure.

VESSELS OF THE TRUNK.

INTERNAL MAMMARY.—Wounds of this artery rarely come under treatment, as its course lies chiefly in front of the heart and great vessels, so that penetrating wounds implicating it are usually immediately fatal from injury to the parts beneath. The *treatment*, in case the patient escapes fatal injuries to deeper parts, is to tie the artery at the wounded spot, if necessary removing a costal cartilage in order to expose it. No other treatment is likely to arrest the bleeding, because of the free anastomoses with the intercostals.

INTERCOSTAL ARTERIES.—These are rarely wounded except in gunshot wounds or stabs fracturing a rib. The hæmorrhage is seldom severe; but should it require *treatment*, the lower border of the rib corresponding to the artery must be exposed by a free incision. On removing the fragments the bleeding artery may come into view, and can be twisted or tied; or it may be turned out of its groove by means of a periosteal elevator, and sufficiently exposed to be tied. If necessary, a piece of rib may be removed to lay bare the vessel more fully. As a temporary means, pressure can be applied thus:—A piece of linen is to be pushed through the wound into the pleural cavity, so as to form a pocket; inside a sufficient quantity of lint or tow is pushed into the pocket to make it too large to pass out by the intercostal space; it is then forcibly pulled upon by the part of the linen outside the chest-walls, and secured in position by a couple of pins pushed across on a level with the skin.

VESSELS OF THE UPPER LIMB.

SUBCLAVIAN ARTERY.—**Wounds of the Subclavian Artery** are almost invariably fatal; though, owing to the protection afforded by the clavicle, they rarely occur except from gunshot injuries or stabs. From the rapidly fatal nature of wounds of the subclavian artery, **Traumatic Aneurisms** in this situation are not met with; but where the artery passes into the axilla below the margin of the first rib, they are not unfrequent.

Aneurismal Varix, resulting from wound of the *Subclavian Artery and Vein*, has been seen, notwithstanding the separation that exists between the two vessels throughout their whole extent. These injuries have likewise usually been the result of sword-thrusts, and do not admit of any surgical interference.

Axillary Artery.—In **Open Wounds of the Axillary Artery and its Branches,** the rule of practice is to expose the bleeding vessel and tie it on each side of the wound. The branches of the artery are so numerous that there must always be some uncertainty, in a case of punctured wound, whether the main trunk or a branch is injured, even when the direction of the wound and the abundance of the bleeding would suggest the former. This doubt can be cleared up only by exposing the bleeding point, and in order to do this efficiently, it may sometimes be necessary to divide both the pectoral muscles across the line of their fibres.

In secondary hæmorrhage, the state of the parts may be such as to make it very difficult to expose the artery cleanly in the wound, and the temptation to apply a proximal ligature under these circumstances is very strong, but this should never be done before a thorough attempt has been made to tie the vessel at the bleeding point, by freely opening up the wound and enlarging it, if necessary. The anastomoses between the branches of the subclavian and the axillary are so free that ligature of the third part of the subclavian is extremely likely to fail. Ligature of the first part of the axillary artery would, in a case of secondary hæmorrhage, be just as difficult as exposing the bleeding point, and could be done after division of the pectoralis major and minor, should it be impossible to secure the vessel at the wounded point. In a case of secondary hæmorrhage, the ligature of the first part of the axillary by a curved incision below the clavicle, as described in Chap. XLIV., Vol. II., would be most difficult; as the axilla would probably be filled with extravasated blood, and the parts matted together by the inflammation and suppuration which caused the failure in the repair of the artery. In all cases of secondary hæmorrhage, it would be safer to expose the artery by an incision in the line of the vessel dividing the pectoral muscles. The subclavian must be tied above the clavicle only as a last resource. The operation has been attended with success enough to justify its adoption should other means fail. Of 15 cases in which it has been performed for hæmorrhage from wounds in the axilla or from stumps, I find that 9 were cured and 6 died.

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In the treatment of the *circumscribed variety* the same principle cannot guide us as in the management of the diffuse extravasation, for not only is the circumscribed aneurism provided with a sac, but the vessel at the point injured will very probably be found to have undergone changes that render it little able to bear the application of the ligature. It will be softened, thickened,

and lacerable, with perhaps a wide funnel-shaped aperture leading into the sac, which will be closely incorporated with the neighbouring parts. But, indeed, the treatment of this form of circumscribed traumatic aneurism by the ligature of the artery on the proximal side of the sac has been found to be attended with remarkable success. In eight recorded cases in which this operation was performed, not one fatal result was noted. In all, the aneurism arose from stabs or gunshot wounds, and had existed for various periods, ranging from two weeks to four years. In four of the cases the artery was ligatured above, and in four below the clavicle: and in one case of each category there was suppuration of the sac.

The particular point at which the artery should be ligatured must depend upon the condition of the tumour. If this be of large size, or arise from the upper part of the axillary artery above or immediately below the pectoralis minor muscle, there is no choice but to deligate the vessel above the clavicle. Should, however, the principal increase in the tumour take place in a direction downwards and forwards under the great pectoral muscle, the portion of the artery immediately below the clavicle not being covered by the sac, the question would arise whether this part might not be selected for the application of the ligature; and as the results of both operations have hitherto been equally favourable, this must rather be determined by the peculiarities in each case than on more general grounds. Most Surgeons, I think, would prefer ligaturing the artery above the clavicle, as being a simpler proceeding than tying it below that bone; the latter procedure, moreover, has the disadvantage of bringing the scalpel into very close proximity with the sac, which, were it to stretch upwards under the pectoralis minor to a greater extent than could be discernible externally, might possibly be opened by the knife, as has happened even in operating above the clavicle.

Compression of the artery on the distal side of the tumour succeeded in curing the disease in a case that was under Goldsmith of Vermont.

BRACHIAL ARTERY.—The hæmorrhage from **Wounds of the Brachial Artery** should be arrested by ligature on each side of the aperture.

This vessel may be punctured in venesection, an accident which was formerly of frequent occurrence when blood-letting was practised by professed phlebotomists; an abundant escape of blood will then occur while the thumb is still on the vein. Should the condition of the patient permit, and the necessary instruments and assistance be at hand, the Surgeon should expose the artery and apply a ligature above and below the wound, at the same time tying the wounded vein. Frequently, however, this treatment will be impracticable, and all that can be done will be to apply a graduated compress. If the patient recover from the disease for which he was bled and an aneurism form, it may be operated on at a later time.

In the **Circumscribed Traumatic Aneurism** at the bend of the arm, following a wound of the brachial artery, we have the usual soft or semi-solid pulsating tumour, which can readily be emptied by pressure, and is accompanied by more or less bruit. This disease may be *treated* in one of three ways: 1, by compression upon or above the tumour; 2, by ligaturing the artery leading to it; or 3, by cutting through the sac, and deligating the vessel on each side of the aperture in it.

Compression has been successfully carried out by means of a graduated compress on the tumour, and a ring-tourniquet on the artery higher up.

Great care must be taken not to induce sloughing of the tissues over the tumour by too forcible pressure. The limb should be carefully bandaged and maintained in the semi-flexed position. Should this plan not succeed, we must be guided by the conditions of the case. If the tumour be of recent origin, soft and compressible, or, though of longer duration, large, with a thin sac, and in danger of becoming diffused, it should be treated by direct incision, and the artery deligated on each side of the wound. Should the tumour be small, or of but moderate size, and the sac be tolerably thick and firm, it has been recommended to treat it by deligation of the brachial artery, either in the middle of the arm, or, as Anel did with success, immediately above the tumour. This mode of treatment is not, however, certainly followed by cure owing to the freedom of the anastomoses about the elbow. I have known it to fail in a case in which the sac was large and thin, the pulsations returning in a few days and the tumour continuing to enlarge. It is better, therefore, in all cases, if pressure fails, at once to have recourse to incision of the sac. With efficient antiseptic treatment the operation is not more dangerous than ligature at a distance.

Varicose Aneurism, at the bend of the arm, presents the ordinary characters of the disease. Occasionally, though rarely, it would appear that the aperture of communication between the aneurismal sac and the vein becomes closed, and thus the varicose is converted into the ordinary circumscribed traumatic aneurism.

The *Treatment* of this affection must be conducted on different principles from that of the ordinary circumscribed variety; for whatever be the density of the sac, it is never, as has already been explained (p. 472), a perfect one, having always an opening into the vein which would prevent its proper closure by the deposit of laminated fibrin. Of four cases related by Sabatier, which were treated by Anel's operation, amputation became necessary in two; and, in the other cases, the operation by incision of the sac was required before a cure could be effected. The sac must therefore be laid open, and the vessel tied on each side of it in the way that has been recommended in the treatment of varicose aneurism, and with the caution there laid down. If the varicose aneurism be converted, after a few days, into the circumscribed form, by the aperture into the vein becoming occluded, the treatment above recommended should be adopted.

In **Aneurismal Varix** of the arm, a roller and compress are all that can be required.

VESSELS OF THE FOREARM AND PALM.—**Wounds of the Arteries of the Forearm** are very commonly caused by pieces of glass or earthenware, or by knives. In every case the bleeding point must be cut down upon, and both ends of the vessel tied. This rule is peculiarly imperative in this situation, on account of the freedom of the anastomoses through the palmar arches. In many of these cases the bleeding is at first very free, but, being arrested by pressure, does not break out again until eight or ten days have elapsed; when, the arm being much infiltrated with blood, inflamed, and swollen, double ligature of the vessel at the seat of injury has to be practised under somewhat difficult and unfavourable circumstances.

Traumatic Aneurism of the Radial and Ulnar Arteries usually assumes the circumscribed form, owing to the pressure employed at the time of injury confining the extravasation. If it be small and recent, and situated

superficially at the lower part of the forearm, or if it be in any way diffused, the better plan is to cut down upon and through the tumour at once, ligaturing the vessel on each side. If, however, the aneurism be deeply seated amongst the mass of muscles at the upper part of the forearm, near the elbow-joint, the wound having healed, and the soft parts covering it being healthy and firm, compression of the brachial, with moderate pressure on the tumour itself, should first be tried, as it has been known to effect a cure. The application of Esmarch's bandage or forcible flexion of the elbow might possibly succeed if simple pressure failed.

If these means fail Liston advised ligature of the brachial artery, but as a rule it is better to open the sac and tie the vessel above and below the opening, as the freedom of the anastomoses round the elbow might cause failure of the treatment by proximal ligature. If the incisions be well planned and efficient antiseptic treatment adopted there is little danger of causing any permanent damage to the limb.

In a case of traumatic aneurism of the radial, just above the wrist, that came under my care, the sac had twice been laid open: the upper end of the radial had been tied; but attempts made to secure the distal end of the artery had been ineffectual, the result being a return of the aneurism, though in a small and more circumscribed form. This I cured by the application of pressure, by means of a small screw-tourniquet attached to a splint, to the radial artery where it lies between the extensor tendons of the thumb, the recurrent aneurism in this case being entirely fed by blood brought to its distal side through the deep palmar arch.

Wounds of the Palmar Arches not unfrequently occur from the breaking of glass or china in the hand, or stabs from some pointed instrument, and are always troublesome to manage. If the Surgeon sees the case shortly after the infliction of the wound, he may endeavour, by carefully enlarging the aperture, with due attention to the tendons and nerves, to reach the bleeding vessel. If the *superficial arch* be wounded, no difficulty will be found in securing it, but if it be the deep, he is very likely to fail. In some cases the artery can be seized in a pair of forcipressure-forceps, which may be left in the wound for twenty-four hours and then carefully removed. Under any circumstances, no effort should be spared to secure the vessel without using the graduated compress. One of the chief dangers of incisions into the palm of the hand is the occurrence of suppuration, extending to the synovial sheaths of the flexor tendons. It is therefore very important that such wounds should be treated antiseptically, well drained, and preserved from every source of irritation. A graduated compress by its pressure causes considerable irritation, and interferes with drainage. Moreover, if a compress is applied with sufficient force to stop the flow of blood through the artery, it must necessarily render the whole area it presses on bloodless. If, therefore, a compress be applied efficiently, and kept on, as is sometimes recommended, for three or four days, it must inevitably cause gangrene of the tissues with which it has been in contact; or, supposing the tissues are not quite dead, acute inflammation will set in as soon as the blood is admitted to them. This has but too often been the experience of Surgeons after the use of the compress; when it has been removed, a foul sloughing wound has been brought into view, with diffuse inflammation spreading round it. Under these circumstances secondary hæmorrhage is very likely to occur.

Still, if all other means fail, the Surgeon must fall back on the graduated compress, which, if well and firmly applied, will often succeed in arresting the bleeding. The proper mode of putting on this compress is as follows :—A tourniquet having been placed on the brachial artery, the whole hand and the wound must be thoroughly cleansed with 1 in 20 carbolic acid lotion. A wooden splint is then to be put on the back of the hand and the lower part of the forearm. The pad must be thickened at its lower end so as slightly to flex the fingers, thus relaxing the palmar fascia. A firm well-made graduated compress of antiseptic gauze or boric lint is now to be applied accurately with the apex downwards to the wound, and securely bandaged against it by a separate bandage. The patient should then be put to bed with the hand elevated. At the end of twelve to eighteen hours the bandage may be carefully removed without disturbing the splint or the compress, and re-applied with just sufficient force to keep the compress in position sticking to the wound without pressing strongly enough to empty the tissues beneath of blood. The patient should be kept for two days in the recumbent position with the hand elevated. It is sometimes recommended that the circulation through the limb should be controlled by a ring-tourniquet, applied on that artery above the wrist which appears most to correspond with the arch wounded, or better still, on the brachial itself; or the elbow may be forcibly flexed, and the fore-arm bandaged to the arm in this position, so that the hand rests upon the shoulder. These precautions are, however, unnecessary, if the compress is properly applied; but they may sometimes be made use of with advantage after the bandage has been relaxed. The compress, after pressure has been relaxed, may be left undisturbed for five or six days, unless there be redness, swelling, and pain, indicating the formation of pus beneath it, when the sooner it is taken off the better. Should the wound be found healing and looking well, there need be no fear of further hæmorrhage; but should the palm be sloughy and infiltrated, there will be a considerable risk of the bleeding recurring. Under these circumstances, it is useless again to resort to compression, and other means must be employed.

Should an ineffectual attempt have been made to arrest the primary hæmorrhage, or should the case not be seen until several days have elapsed, when secondary hæmorrhage has occurred, and the palm has become infiltrated and swollen, pressure can no longer be borne upon the seat of injury, and it may be almost impracticable to endeavour to search for the injured vessel in the midst of sloughy and infiltrated tissues. By applying a tourniquet to the arm, and carefully enlarging the wound and scraping away the sloughy tissue with a sharp spoon, the bleeding vessel has, however, been ligatured successfully in some cases. Failing this, it is necessary to deviate from the ordinary rule of practice, and the operation of proximal ligature may be performed. The Surgeon may either tie both arteries above the wrist, or at once deligate the brachial. Both methods of treatment have their advocates. I prefer the simultaneous ligature of the two arteries of the forearm, just above the wrist, where they are superficial and very easily reached. In several cases under my care, the radial and ulnar, immediately above the hand, have been tied at the same time with complete success, and I have never seen a case in which this operation has failed ; but should hæmorrhage occur after it, as might happen in the case of an enlarged

median or interosseous artery, the Surgeon must have recourse to compression or ligature of the brachial.

Circumscribed Traumatic Aneurism in the Palm is by no means of frequent occurrence. It may, however, follow wounds of the palmar arches. In such a case as this, forcible flexion of the elbow or the application of Esmarch's bandage might be tried. If these fail it would clearly be out of the question to lay open the sac, and to search for the injured vessel in the midst of the aponeurotic and tendinous structures of the hand. It would consequently be necessary, either to tie the radial and ulnar arteries immediately above the wrist, or to ligature the brachial in the middle of the arm. The latter plan should be preferred ; as, were the first mode of treatment put into practice, the sac might continue to be fed by the interosseous artery, as happened in a case of Roux's, in which the patient died of hæmorrhage from the palmar aneurism after ligature of both arteries of the forearm. In the case represented (Fig. 150) Liston successfully ligatured the brachial in the mid-arm, after compression upon it had failed to effect a cure.

VESSELS OF THE LOWER LIMB.

GLUTEAL ARTERY.—**Traumatic Aneurisms of the Gluteal Artery** are of less frequent occurrence than might *a priori* have been imagined, from the situation of the vessel exposing it to injury. These aneurisms may acquire an enormous size, and are often accompanied by much redness and œdema of the skin covering them. Pulsation may be indistinct or absent, and thus such cases may closely resemble large abscesses and have been more than once mistaken for them. In John Bell's celebrated case, the tumour is said to have been of "prodigious size," and to have contained eight pounds of blood. In Syme's case the tumour was as large at the base as a man's head, occupied the whole hip, and rose into a blunt cone.

The *Treatment* that should be adopted is to compress the aorta by means of the aortic tourniquet; then to lay open the tumour freely, turn out its contents, and pass a ligature by means of an aneurism-needle round the short trunk of the gluteal as it emerges from the pelvis.

EXTERNAL ILIAC ARTERY.—Wounds of this vessel must almost invariably be fatal. If, however, the bleeding has been temporarily controlled by pressure, an aortic tourniquet should be applied, the wound enlarged and the vessel ligatured above and below the puncture.

In a case of **Circumscribed Traumatic Aneurism** following a wound with a pocket-knife, Clutton successively ligatured the external iliac artery above and below the sac.

FEMORAL ARTERY.—The hæmorrhage from the **Femoral Artery, Common, Superficial or Deep,** when wounded is always very profuse. In all cases, ligature of the vessel at the seat of injury should be practised.

If a **Diffused Traumatic Aneurism** have already formed, the artery should be commanded by a tourniquet or by pressure on the aorta, the sac laid open, and the bleeding vessel tied. Guthrie has collected a great number of cases, which prove incontestably that the general principles of treatment of wounded arteries must not be departed from, when the arteries of the groin or thigh are wounded. On the contrary, the facility with which in most cases the circulation is kept up, and the readiness with which secondary hæmorrhage

comes on as a consequence of the free anastomoses in this situation, render the rule of applying a ligature on each side of the wound peculiarly stringent in all such cases. Secondary hæmorrhage and gangrene of the limb are the great sources of danger here. When gangrene is imminent, or has come on, amputation is necessarily the sole resource. With regard to secondary hæmorrhage supervening after ligature of the artery *at the seat of injury*, there is, I think, no safe course but removal of the limb. Where the artery has been tied higher up, as, for instance, when the external iliac has been ligatured for recent wounds or traumatic aneurisms in the groin or upper part of the thigh, the hæmorrhage appears to have returned, or gangrene to have supervened in all cases. This fact was remarkably illustrated in the Crimean War. Thus, Macleod states that the French in one hospital at Constantinople ligatured the femoral at a distance from the wound for secondary hæmorrhage seven times, and that all the cases failed.

If the traumatic aneurism have assumed a *circumscribed* character, it must be treated on the principles laid down for this form of the disease, the supplying artery being ligatured above the tumour; and cases are not wanting in proof of the success of this practice.

It occasionally, though rarely, happens that a **Varicose Aneurism** is formed in the groin or upper part of the thigh, as the result of wound of the artery and vein in this situation. It usually presents the ordinary characters of this disease, but some peculiarities have occasionally been met with. Thus, in a case related by Horner, there was a wavy motion in the femoral vein on the uninjured side, arising from the blood in the wounded vessel communicating a thrill upwards to that contained in the vena cava. In a case related by Morrison, it is stated that a tumour, as large as the human uterus at the third month of pregnancy, communicated with the injured vein.

The *Treatment* of this disease is exceedingly unsatisfactory. Of four cases in which the external iliac artery was tied, a fatal termination occurred in every instance; two of the patients dying of gangrene of the limb, and the remaining two of secondary hæmorrhage and consecutive pneumonia. It was consequently proposed by Guthrie that the tumour be laid open, and the artery secured above and below the aperture in it. As this plan has never been fairly put into practice, it would perhaps be useless to speculate on the chances of success likely to attend it. The danger of a fatal gush of blood on laying open the sac, which in former times would have made most Surgeons hesitate to venture on such an operation, has now been completely obviated by the use of the aorta-compressor.

Vessels of the Leg and Foot.—Deep stabs, cuts, and gunshot wounds of the leg may be followed by profuse hæmorrhage from a wounded artery. It may not always be easy to determine with accuracy which of the arteries is wounded: whether it be one of the tibials, the peroneal, or only large muscular branches. This is more especially the case when, in consequence of fracture, a pulsating extravasation of blood forms in the calf. When there is an open wound, the direction taken by it will probably enable the Surgeon to solve the question.

In the *Treatment* of arterial bleeding from the leg, the Surgeon may, especially if it be not very profuse, try to arrest it by compress, bandage, and position. Should these measures fail, recourse must be had to operation.

When the **Posterior Tibial Artery** is wounded, there is no reason to

deviate from the usual principle of treating primary hæmorrhage from a wounded artery, viz., to cut down on the vessel at the seat of injury, and tie it above and below the wound in it. The same rule of treatment applies to **Wounds of the Anterior Tibial and Peroneal Arteries.** In performing this operation, if the posterior tibial be wounded in the upper two-thirds of its course, the Surgeon will have to cut freely by the side of or through the muscles of the calf. This he must do in the direction of their fibres, injuring them by transverse incision as little as possible ; and by taking the track of the wound as his guide, the bleeding vessel will at last be reached, and must then be tied in the usual way. Such an operation, practised on a person with a muscular limb that is infiltrated with blood and inflammatory effusions, is in the highest degree difficult. In the lower third of the leg the arteries are superficial, and are reached with comparative ease.

When the hæmorrhage is *secondary*, or if a diffused aneurism have formed, with or without external wound, as in a case of fracture, the Surgeon may, by means of the bloodless method, succeed in applying a ligature to the wounded vessel. Thus, Battle, in a case of diffused traumatic aneurism of the calf, which was mistaken for an abscess, successfully ligatured the lower end of the popliteal and both the tibial arteries. Recourse has, however, occasionally been had to ligature of the superficial femoral with success. The vessel may be tied in Scarpa's triangle, or, which would, I think, be better in such a case, in Hunter's canal. If this fails, amputation is necessarily the only resource. In one of the successful cases S. Cooper ligatured the popliteal—a plan that has found favour with the French Surgeons. In another, Dupuytren tied the superficial femoral for a pistol-bullet wound in the leg. The others were cases of diffused aneurism, arising from secondary hæmorrhage occurring in the course of a fracture.

The subject of **Wounds of the Tibial Arteries** as a result of fracture of the tibia, will be more fully discussed in Chapters XX. and XXI.

Small **Circumscribed Aneurisms** are occasionally met with in the foot, in consequence of wound of one of the plantar arteries, as in operations for club-foot. If pressure have failed in preventing or curing the disease, the only course left to the Surgeon is to lay the tumour open, and to ligature the artery on each side in the usual way.

CHAPTER XVII.

ENTRANCE OF AIR INTO VEINS.

The Entrance of Air into a Wounded Vein, though a rare accident, is one of great interest to the practical Surgeon, as it occurs chiefly in the course of operations.

It was first observed in the year 1818, in a case in which the internal jugular vein was opened during the removal of a large tumour from the right shoulder by Beauchesne, and the subject was afterwards fully investigated by a Commission of the French Academy, by Magendie, Amussat, Cormack, and others.

Results of Experiments on Animals.—As cases of entry of air into the veins occur comparatively seldom in man, it is necessary to study the phenomena accompanying it on the lower animals. The experiments of Morgagni, Valsalva, Bichat, and Nysten long ago demonstrated the fact that the forcible introduction of air into the circulation would kill an animal. Death in these cases appears to be dependent partly on the quantity of air injected, and partly on the rapidity with which it is thrown in. Bichat supposed that a single bubble would kill with the rapidity of lightning; but this is erroneous. I have on several occasions injected two or three cubic inches of air into the jugular vein of a dog, without producing death, though much distress resulted. The rapidity with which the air is thrown in exercises a considerable influence upon the result: if quickly, a small quantity may kill; if slowly and gradually, a large quantity may be injected without destroying life, the blood apparently absorbing the gas. In experiments I have observed the following phenomena in cases where death was produced.

On exposing the internal jugular vein low in the neck, and puncturing it at a place where the flux and reflux of the blood are plainly discernible, there is perceived in the first inspiratory effort made by the animal after the wound, a peculiar lapping or gurgling, hissing sound; the nature of the sound depending partly on the size and situation of the opening in the vessel. At the same time, a few bubbles of air are seen to be mixed with blood at the orifice in the vein. The entrance of the air is immediately followed by a struggle, during the deep inspirations of which, fresh quantities of air gain admittance, the entrance of each portion being attended by the peculiar sound above described. On listening now to the action of the heart, a loud churning noise will be heard with the ventricular systole; and the hand applied to the chest will feel at the same time a peculiar bubbling, thrilling, or rasping sensation, occasioned by the air and blood being whipped together amongst the columnæ carneæ and chordæ tendineæ. As the introduction of air continues, the circulation becomes gradually more languid; the heart's action, however, being fully as forcible as natural, if not more so. The animal soon becomes unable to stand; if placed upon its feet, it rolls over on one side,

a few plaintive cries, is convulsed, passes fæces and urine, and dies. thorax be immediately opened, it will be seen that the heart's action is ing regularly and forcibly, and that the right cavities, though filled, appear abnormally distended.

h occurs, as I have shown in a paper on this subject, published in the number of the *Edinburgh Medical and Surgical Journal*, in consequence air and blood being beaten up together in the right cavities of the heart spumous froth, which cannot be propelled through the pulmonary ; hence there is a deficient supply of blood to the brain and nervous , and fatal syncope comes on, attended usually with convulsions. In n to this, the frothy mixture in the ventricles has not sufficient resistance s upon and close the valves of the heart, and the circulation consequently mes to a stand-still.

TANEOUS ENTRY OF AIR INTO THE VEINS OF MAN is attended with ad constitutional phenomena.

al Phenomena.—These consist of a peculiar sound, produced by the e of the air, and of the appearance of bubbles about the wound in the The sound is of a hissing, sucking, gurgling, or lapping character, and fails to indicate the serious nature of the accident that has occurred. once heard, whether in man or in the lower animals, it can never be en. It has fortunately fallen to my lot to hear this sound in the human on one occasion only, in a patient who had attempted suicide by his throat. The wounded internal jugular was being raised for the e of having a ligature passed under it, when a loud hissing and gurgling was heard, and some bubbles of air appeared about the wound; the became faint, and greatly oppressed in his breathing. The ligature mediately tightened, the faintness gradually passed off, and no bad uences ensued.

Constitutional Effects are usually very marked. At the moment of f the air, the patient is seized with extreme faintness, and a sudden ion about the chest; if he is not unconscious from an anæsthetic he s out or exclaims that he is dying, and continues moaning. There is a, purely cardiac in character, for the air enters the lungs freely; this f dyspnœa is due to the arrest of the supply of blood to the lungs. lse becomes nearly imperceptible, though the heart's action is laboured pid; the pupils are widely dilated. Death commonly results; but not aneously, in many cases at least. Greene has collected 68 fatal cases of cident: 24 died almost immediately, the rest at periods varying from hours to seven days. Beauchesne's case lived a quarter of an hour e occurrence of the accident. If the patient survive the immediate of the accident, he may recover without any bad symptons, as happened case to which I have referred above, and in an instance recorded by per. In some of the cases that survived some days the fatal result is have been due to bronchitis or pneumonia.

se.—The cause of the entry of air into the veins was very com- investigated by the French Commission. If we open a large vein at t of a dog's neck, in which the venous pulse, or flux and reflux of the is perceptible, we shall see that air rushes in during inspiration only. owing to the tendency to the formation of a vacuum within the thorax inspiration. This suction action, or "venous inspiration," is confined

to the large vessels in and near the thoracic cavity, being limited by the collapse of the coats of the veins at a little distance from this. If the veins were rigid tubes, it would extend throughout the body; but as they are not, it ceases where the coats collapse. The root of the neck and the axilla where the venous flux and reflux are perceptible have, therefore, been termed the "dangerous region." In certain circumstances, however, air may spontaneously gain admission at points beyond this.

It is well known that what is called by the French Surgeons the "canalization" of a vein, or its conversion into a rigid uncollapsing tube, is the condition which is most favourable to the entry of air. Indeed, except in the so-called "dangerous region," this accident cannot occur unless these vessels be canalized, or, in other words, prevented from collapsing. Canalization may be brought about in a variety of ways. Either the cut vein may be surrounded by indurated tissue, which keeps it open like a hepatic vein; or its coats may have been thickened by inflammation to such a degree as to prevent their falling together when divided. Then, again, some of the veins at the root of the neck, especially the external jugular, have such intimate connections with the cervical fascia that their sides may be held apart when they are cut across. The contractions of the platysma and other muscles of the neck may likewise have a similar effect. In removing a tumour, also, from the lower part of the neck or axilla, the traction exercised upon its pedicle may cause a vein to become temporarily canalized; especially if the section be incomplete and in a transverse direction, when the wound will be rendered open and gaping by the traction upon it. This patency of the incision in the vein is apt to be increased by the position that is necessarily given to the head and arm, in all operations of any magnitude about the axilla and neck. Lastly, the introduction of air into a vein will be favoured by the vessel being divided in the angle of a wound, the vein being made open-mouthed and gaping when the flaps that form the angle are lifted up.

In all cases in which air has entered the veins during operations these vessels were in one or other of the above-mentioned conditions. Thus, in Beauchesne's case, air was introduced in consequence of incomplete division of the external jugular, immediately above the right subclavian, whilst in a state of tension, during the removal of a portion of the clavicle. In a case that occurred to Dupuytren, a large vein connected with a tumour and communicating with the jugular was cut whilst the tumour was being forcibly drawn up. The vein was found to be adherent to the sides of a groove in the growth, so that it remained gaping when cut. In a case related by Delpech, there was thickening of the coats of the axillary vein, causing it to gape like an artery. Ulrick saw the accident occur in consequence of the incomplete division of the internal jugular vein, which was implicated in a tumour in the neck. A similar case happened to Mirault of Angers, the internal jugular being divided to half its circumference. A case occurred to Warren, in which the air entered by the subscapular vein, the coats of which were healthy, but in a state of tension in consequence of the position of the arm; and another, in which the same accident happened from the division of a small transverse branch of communication between the external and internal jugular, whilst in a state of tension. Mott, whilst removing a tumour of the parotid gland, opened the facial vein, which was in a state of tension in consequence of the position of the patient's head, when air was introduced. Bégin also relates a

case in which air entered in consequence of the puncture of the internal jugular vein whilst he was removing a tumour from the neck.

These cases show clearly what the Surgeon should particularly guard against in the removal of tumours about the neck and axilla; viz., incomplete division of the veins, and the employment of forcible traction on the diseased mass at the moment of using the scalpel. In removing tumours from the neck and axilla, it is in many cases impossible to avoid drawing them forcibly upwards or forwards, in order to get at their deeper attachments; but if this be necessary the chest should, for reasons that will immediately be pointed out, be tightly compressed, so that no deep inspirations may be made at the moment that the knife is being used, or before a divided or wounded vein can be effectually secured.

Preventive Treatment.—In the pre-anæsthetic days, this accident was of more common occurrence than it is now. When a patient was under the knife, the respirations were generally shallow and restrained, the breath being held, whilst every now and then there was a deep gasping inspiration; at which moment, if a vein were opened in which the pulse were perceptible, or which was canalized, air was necessarily sucked in, in quantity and force proportioned to the depth of the inspiration. In these circumstances, it was recommended that the chest and abdomen should be so tightly bandaged with broad flannel rollers as to prevent the deep gasping inspirations, and to keep the breathing as shallow as possible, consistently with the comfort of the patient. I have often found that the entrance of air into the veins of a dog could be arrested by compressing the chest of the animal, so as to limit the respiratory movements; but that, as soon as a deep inspiratory effect was made, on the compression being removed, a rush of air took place into the vessel. When such precautions were taken, therefore, during an operation about the root of the neck, the Surgeon had to be careful not to remove the compression until the operation was completed, and the wound dressed; for if this precaution was not attended to, the patient would, most probably, on the bandage being loosened, have made a deep inspiration, and air might have been sucked in at the very moment when all appeared safe. It is now rarely possible to adopt these precautionary measures, for the danger from applying such constriction during the administration of an anæsthetic would be greater than the risk of entrance of air, but I have allowed this description of them to remain partly on historic grounds and partly because circumstances might even now arise in which they might be necessary.

In the removal of cancerous glands or other tumours from the axilla, it is sometimes possible to compress the vein, between the heart and the place of operation.

Curative Treatment.—Different plans have been recommended for the treatment of those cases in which air has gained admittance into a vein; but, from the very fatal nature of this accident, it does not appear that much benefit has resulted from any of them: the recovery of the patient, in some of the cases, appearing to be due rather to the quantity of air that was introduced being insufficient to cause death, than to any effort on the part of the Surgeon. The suggestion of Amussat and Blandin, to empty the heart of the mixture of blood and air by suction through a tube passed into the wound in the vein, or into an opening made into the right jugular, can hardly be considered within the range of practical Surgery. The compression of the

chest recommended by these observers, and by Gerdy, however valuable it may be in preventing the ingress of air, can, when it has once been introduced into the veins, have no effect in removing it. Bleeding from the temporal artery, opening the right jugular vein, and even tracheotomy, are other measures which have been recommended, but are unlikely to be productive of anything but harm.

1. What, then, are the measures that a Surgeon should adopt? Beyond a doubt, the first thing to be done is to **prevent the further ingress of air**, by compressing the wounded vein with the finger, and, if practicable, securing it by a ligature, as it is only when the air that is introduced exceeds a certain quantity that death ensues. All further entry of air having been thus prevented, our next object should be to **keep up a good supply of blood to the brain and nervous centres**, and thus maintain their activity. The most efficient means of accomplishing this would probably be the plan suggested by Mercier, who recommends us to compress the abdominal aorta and axillary arteries, so as to divert the blood that may pass through the lungs to the encephalon. This appears to me to be the most effectual way of carrying out the indication. The patient should, at the same time, be placed in a recumbent position, so as to facilitate the afflux of blood to the head. The compression of the axillary and femoral arteries may readily be made by the fingers of two assistants.

2. **To maintain the action of the heart** until the obstruction in the capillaries of the lungs can be overcome or removed, artificial respiration should be resorted to as the most effectual means of keeping up the action of that organ. It also helps the circulation through the lungs, and thus relieves the right side of the heart. Silvester's method of artificial respiration is the best, (see Chap. XXVII.) but before employing it, it will be necessary to remove everything that compresses the chest, or interferes in any way with the free exercise of the respiratory movements. Friction with the hand over the præcordial region, and the stimulus of ammonia to the nostrils, may at the same time be resorted to.

3. The third indication—that of **overcoming the obstruction in the pulmonic capillaries**—would probably be best fulfilled by the means adopted to maintain the heart's action, viz., artificial respiration. That the action of respiration, if kept up sufficiently long, will enable the capillaries of the lungs to get rid of the air contained in them, appears to be certain; for I have experimentally observed that, if a certain quantity of air be introduced into the jugular vein of a dog, and artificial respiration be then established, and maintained for half or three-quarters of an hour, a very small quantity indeed, if any, will be found, on killing the animal, in the cavities of the heart, or in the branches of the pulmonary vessels. I am aware that this is not altogether conclusive, as the air might be dissolved in the blood, or might still exist in the capillaries of the lungs, although none might be found in the larger branches of the pulmonary artery; but still it seems to me that we can hardly account for the large quantity of air that will disappear when artificial respiration is kept up, in any other way than by assuming that some, if not all of it, passes out of the capillary vessels into the air-cells of the lungs.

CHAPTER XVIII.

SPECIAL INJURIES OF NERVES, MUSCLES, AND TENDONS.

INJURIES OF NERVES.

CONTUSION.—Nerves are often contused; the injury producing a tingling sensation at their extremities, and pain at the part struck. These effects usually pass off in the course of a few minutes or hours. If the blow have been sufficiently severe to cause hæmorrhage amongst the fibres of the nerve, the symptoms may be more severe and persistent, and temporary paralysis of the parts supplied by the injured nerve may result. Most commonly sensation is merely impaired, even when the motor paralysis is complete. In hysterical women, the symptoms may last for a considerable period, and even slight contusions may give rise to very persistent neuralgia. In other cases the continuance of the symptoms appears to be due to the supervention of chronic neuritis (see p. 497).

STRAINS.—Any movement, which stretches a nerve forcibly, may be slowly followed by the symptoms of chronic neuritis to be described later on (p. 497). This is most common in the nerves of the brachial plexus.

COMPRESSION.—This most commonly arises from the pressure of tumours or aneurisms, but it may be the result of injury; thus, the brachial plexus may be pressed on by the head of the humerus in a dislocation, the spinal nerves may be compressed at the intervertebral foramina in cases of fracture of the spine, and the fragments of bone in a fracture of a limb may press on contiguous nerves. Another common form is the so called crutch-palsy, resulting from the pressure of the upper end of the crutch upon the nerves of the brachial plexus; a similar paralysis of the muscles of the front of the leg is not uncommonly met with, as the result of pressure on the external popliteal as it winds round the head of the fibula, from splints applied without sufficient padding; and I have known of three cases in which the musculo-spiral nerve was paralysed from the arm hanging over the edge of the table during a prolonged operation. In these cases sensation is little, if at all, impaired. Nerves may also be compressed by the growth of callus from a fractured bone, or by the contraction of a scar. The effects of pressure are proportional to its severity and duration. The mildest effects are the numbness, tingling, and sense of weakness with which everyone is familiar as a consequence of pressure on the ulnar nerve from sleeping with the arm under the head. If it lasts for a sufficient length of time, and is sufficiently severe, complete loss of sensation and paralysis are produced in the parts supplied by the nerve pressed upon, followed by wasting and degeneration of the muscles. Such cases usually recover in time, if the cause be removed and the limb be afterwards treated by the methods described later on.

RUPTURE OR LACERATION.—Healthy nerves are rarely torn across except in the most severe injuries, such as compound dislocations and compound fractures. When paralysis or loss of sensation follows a subcutaneous injury, it is due to contusion, and possibly to rupture of some of the fibres, but the continuity of the nerve is scarcely ever completely interrupted.

PUNCTURE.—If a nerve be punctured, the parts below the puncture become the seat of tingling, shooting, and burning pains, and the neuralgic condition may travel upwards along the nervous trunk. Thus, I have more than once seen a puncture of one of the digital branches of the ulnar nerve produce a kind of painful paralysis of its trunk, rendering the arm nearly useless. I have seen the same effects occur in the median nerve from a needle puncture of the finger. It occasionally happens, in venesection at the bend of the arm, that a branch of the internal cutaneous nerve is pricked, and that very persistent neuralgia occurs in consequence.

DIVISION.—**Primary Effects.**—When a nerve is completely cut across, or its conducting power is in any way abolished, whether by contusion, compression, or laceration, paralysis of sensation or motion, or both, according as the nerve is sensory, motor, or mixed, occurs in all the parts surplied by it. The vaso-motor paralysis that arises from the division of the nerve at first causes hyperæmia, with some elevation of temperature, which only lasts for a few days and then gradually subsides till in a week or two the part becomes passively congested and colder than natural. The patient complains of numbness or deadness in the parts supplied by it, and sensibility of every kind is lost; but various anomalous painful sensations of a burning, tickling, tingling, or creeping kind are complained of. These sensations often give the idea of increased heat of the part to the patient, and are compared by him to the effect that would be produced by molten lead or boiling water running through it. When the nerve is partially divided, or bruised as well as severed, as in cases of gunshot injury, neuralgia in the parts supplied by it beyond, and sometimes also in those above, the seat of injury, is associated with the paralytic symptoms.

The **Secondary Effects** of division differ according to the nature of the nerve.

The section of a purely *motor nerve*, such as the facial, causes complete paralysis, with subsequent wasting and degeneration of the muscles supplied by it, but the nutrition of the superficial structures is not affected.

The changes in the muscles in these cases are of great importance. From the moment the nerve is divided, all voluntary power is of course lost. The conductivity of the nerve is rapidly abolished; it begins to be lowered at the middle of the first week, and at the end of the second week stimulation of the lower end of the divided nerve with the constant or interrupted current fails to cause any muscular contraction.

Direct excitation of the muscle shews that during the first two weeks after the nerve section the irritability to the voltaic and faradic currents are both lowered. The faradic excitability now entirely disappears, whilst at the same time the contractions produced by the constant current become excessive and remain so for several months, after which the excitability falls and disappears altogether in a year or more. These reactions are most useful guides in diagnosis, prognosis, and treatment. As the muscles become flabby and wasted, deformities of various kinds may ensue, from the unopposed action of

the unaffected muscles of the limb, or from shortening of the paralyzed and atrophied muscles, should their points of attachment be approximated by the position in which the limb is placed.

The division of a purely *sensory nerve*, such as a branch of the fifth, completely abolishes sensation in the part supplied by it, but does not necessarily cause any serious disturbance of nutrition. This is probably due to the free communication between the various nerves of the face. Arloing and Tripier have shown by experiment that, after the division of a superficial sensory nerve, the neighbouring cutaneous nerves which communicate with the terminal branches of the one divided rapidly assume its functions so that sensibility may return in a few days without repair of the divided nerve. If the whole trunk of the fifth nerve is destroyed together with the Casserian ganglion, serious interference with nutrition follows, such as ulceration of the cornea or of the nasal mucous membrane. In central disease affecting the fifth nerve, the ganglion remaining intact, trophic changes do not occur, although, from loss of sensibility, the parts supplied by it are prone to suffer from injury. It may, in fact, be stated as a general rule that grave trophic changes do not occur unless a part is completely cut off from all communication with a healthy nerve-centre.

After the division of a *mixed nerve*, such as the ulnar, the nutrition of the part supplied by it is seriously modified. The muscles, as before stated, degenerate and waste. The whole part supplied by the injured nerve becomes congested, bluish, and, after a temporary rise of temperature in some cases, colder than natural. The fall of temperature is often very marked. Thus, I found in a woman who was under my care for a wound of the forearm, in which the ulnar nerve had been divided, that, twenty-one days after the injury, the temperature between the ring and the little finger of the injured side was 9° Fahr. below that of the same spot on the opposite hand. Sometimes the part becomes œdematous; the skin often becomes rough and peels, but more commonly it is smooth, red and shining—the "glossy skin" of Paget; the nails grow badly, and are brittle or scaly, and abnormally curved longitudinally. Gradually increasing stiffness, with sometimes painful swelling, of one or more of the joints of the fingers may occur. Blebs, the contents of which become purulent, not uncommonly form on the tips of the fingers. Chilblains are readily produced by slight exposure to cold, and they frequently become vesicular or slough, leaving sluggish and unhealthy ulcers. Wounds in such parts heal badly, and are peculiarly prone to be affected by unhealthy spreading inflammations. If the patient be a growing child, the development of the affected part will be more or less completely arrested.

If union takes place between the opposite ends of the divided nerve, the various phenomena that have just been described gradually disappear, and complete restoration, first of sensation and afterwards of motion, with a return to the normal nutrition of the part, eventually takes place. Some voluntary motion usually returns in the muscles before electrical irritability is re-established. In many cases, however, especially if a piece of the nerve have been removed, or if the wound in which it has been divided heal by the second intention, recovery fails to take place. Under these circumstances, the central end becomes bulbous, just as in similar conditions in stumps, and it may then become the seat of intense neuralgic pains darting downwards to

the terminal branches and upwards along the trunk of the affected nerve.

Pathology.—If a nerve be completely divided its two ends retract very slightly; not more than a sixteenth of an inch. In cases which have been examined at a later period, the separation has been found to have increased to about a third or half an inch, or even more. *Degeneration* sets in in the peripheral end about four days after it has been cut off from its communication with the nerve-centres. The nuclei of the primitive sheath of Schwann proliferate. The medullary sheath undergoes segmentation, then breaks up into irregular globules and finally disappears entirely in about a month. The axis-cylinder degenerates at a later period, but after some weeks it also breaks up and disappears. The nerve then consists merely of the shrunken sheath of Schwann, containing some granular protoplasm and nuclei, and the connective tissue of the fibrous sheath. In the central end degeneration extends only a very short distance from the injury, and commences at a later period. Within a few weeks of the injury the proximal end will always be found to have become more or less distinctly bulbous, the bulb being composed of fibrous tissue in which many new nerve fibres are commonly found. Bowlby states that the *regeneration* of the distal end may occur without union of the divided nerve, but Ranvier believes this takes place only when there are free communications between the fibres of neighbouring nerves and those of the divided nerve. In a case lately in University College Hospital the state of the nerves confirmed this latter view: three years after division the distal end of the ulnar, which has but few communications with any other nerve, showed no signs of regeneration, while that of the median which communicates freely with the radial, which was not divided, contained multitudes of tubules with healthy medullary sheaths. When the ends of the divided nerve are brought in contact directly after division it has been asserted that *immediate union* may occur. It is difficult in any other way to explain the fact that in some exceptional cases sensation has commenced to return in the parts supplied by the divided nerve within twenty-four hours of the approximation of the ends by suture. Under ordinary circumstances the first step is the formation of a bond of union between the two ends composed of a delicate spindle-cell tissue. By what process the new nerve-tubules are developed in this mass of young connective tissue is still doubtful. Cornil and Ranvier assert that a growth takes place from the axis-cylinders of the proximal end which penetrate the new tissue and communicate with the lower end, becoming subsequently clothed with the medullary sheath. Before the nerve can resume its functions, the whole peripheral part, which has, as before stated, undergone degeneration, must be regenerated. The regeneration of the degenerated tubules is believed to take place from the nuclei of the sheath of Schwann, which remain even in the atrophied nerve after the medullary sheath and axis-cylinder are gone. These multiply and join with each other to form the new axis-cylinder, which subsequently becomes surrounded by the medullary sheath. The process of regeneration is said to proceed gradually down the nerve from the injured spot. The restoration of a divided nerve is in most cases slow, and is often not complete for from three months to a year. The period at which signs of returning function have manifested themselves varies much. In some rare cases sensation has commenced to return in from twenty-four hours to six days, in others not for many months.

TREATMENT OF INJURIES CAUSING INTERRUPTION OF THE CONDUCTING POWER OF A NERVE.—The treatment of these injuries may be divided into two parts: 1st, the *Local treatment of the Injured nerve*, and 2ndly, *the Treatment of the Paralysed part.*

1. The **Local Treatment.**—In cases of *subcutaneous injury* nothing should be done, for it may be taken for granted that, although the nerve may be completely paralysed, its continuity is not destroyed. On dissecting limbs amputated for the most severe railway or machinery accidents, the nerves are almost invariably found untorn in the midst of the crushed tissues. To cut down, therefore, in a subcutaneous injury with the intention of suturing the nerve would be a grievous error. When the function of the nerve is abolished by *pressure*, the cause of pressure must be removed if possible, as by the cure of an aneurism, the excision of a tumour, or the reduction of a dislocation. When the cause of the paralysis is the *implication of the nerve in a cicatrix or in the callus of a fracture*, nothing should be done locally until, after waiting many months, it becomes evident that nature will not effect a cure. It will very rarely be found necessary in such cases to adopt any operative plan of treatment, the symptoms disappearing as the scar becomes looser with age, or as the provisional callus of the fracture is absorbed. Warren, however, relieved a case of neuralgia resulting from implication of a nerve in cicatricial tissue by dissecting it out without dividing or otherwise injuring it.

Primary Suture.—In cases of *division of a nerve in an open wound* no doubt exists as to the proper line of treatment: the two ends of the nerve should be found and carefully secured to each other by fine sutures. The best material for suture is very fine chromic catgut. Silk, which would not be absorbed for many weeks, might cause irritation and possibly severe neuralgia. The needle should be a common round sewing needle, which, if necessary, can be bent into a curve in the flame of a spirit-lamp and hardened again by being dipped in cold water; the ordinary flat surgical needle, with its cutting edges, needlessly damages the nerve. The end of the nerve should not be pinched with the forceps, as this may prevent rapid union. The sutures should be passed completely through the nerve, not through the sheath only, as this ensures better approximation of the ends. Three or four sutures having being applied, according to the size of the nerve, the wound must be closed and treated by some antiseptic method if possible; suppuration being usually fatal to success. The limb must be put in such a position as completely to relax the nerve. In a large proportion of the cases union will be obtained, with restoration of function.

The *prognosis* after primary nerve suture is good, but the period at which restoration of function may be expected varies greatly. Reference has already been made to these exceptional cases in which a rapid return of function has suggested the occurrence of primary union. Bowlby concludes from the consideration of a large number of cases that recovery may occur after weeks, months, or years; he finds that improvement usually begins within a year, but that a case cannot be looked upon as quite hopeless until the lapse of two or three years.

Secondary suture may be undertaken if the primary operation has failed, or if no attempt was made to suture the nerve at the time of the injury.

The operation is performed by freely exposing the nerve after rendering the limb bloodless. Its proximal extremity can sometimes be found by its bulbous

condition, which may perhaps be felt; the lower end is often atrophied and more difficult to find. The ends of the nerve may then be pared, so as to remove the dense scar-tissue with which they are covered, but no more should be taken away than is absolutely necessary. After this they are sutured as in a fresh wound. Great care must be taken to relax the nerve by a suitable position of the limb. The operation of nerve-grafting has met with sufficient success to justify its trial in cases where it is found impossible to approximate the ends of the nerve.

Prognosis.—Bowlby has collected 73 cases of secondary nerve suture, in 32 of which the result was successful, in 26 partially successful, whilst in 15 no improvement followed. The ultimate results were, however, probably more favourable than these figures indicate, as many of the cases, especially the partially successful ones, may have continued to improve later. Great improvement may be confidently expected, and no case must be despaired of until several years have passed. The operation should be undertaken, however long the time may be that has elapsed since the injury, and however marked may be the atrophy of the paralysed muscles.

2. **Treatment of the Paralyzed Limb.**—In all those cases in which the nerve is not completely divided, treatment of the paralyzed parts is alone possible, the object being to prevent wasting and to maintain the nutrition of the limb in such a way that, when restoration of the nerve takes place, the muscles shall be in a state to respond to the influence of the will. Much can be done by judicious treatment to maintain the temperature, to avoid the formation of chilblains and other sores, to prevent the development of deformities, and in children or young subjects to keep up the growth. In order to keep up the nutrition and to overcome the congestion which is always met with in the paralyzed part, it must be made of a healthy red colour at least twice a day. There is no more efficient means of doing this than the use of the continuous electric current. The sponge connected with the positive pole of the battery may be applied over the course of the nerves, while the limb is freely sponged with the other. At the same time each separate muscle should, if possible, be made to contract by slow interruptions of the current. In a minute or more the whole paralyzed part will become bright red. In the absence of the battery, much may be done by properly applied rubbing. The part should be carefully protected by warm clothing, and the patient should be encouraged to use it as much as possible. If only a single group of muscles is paralyzed, properly designed apparatus may be required to overcome the deformity which ensues, but this should never be used if it can be avoided, as it interferes to some extent with the use of the limb.

Traumatic Neuritis.—This disease may follow almost any injury of a nerve. It is most common in civil practice as the result of bruises or strains, and is sometimes connected with gout or rheumatism. In wounds it seldom arises unless union has taken place by the second intention with inflammation and suppuration; and, consequently, it is a rare affection in amputation stumps. In gunshot wounds, in which the nerves are often contused and partially divided and in which the wound almost always heals with suppuration, is more common.

Pathology.—Acute inflammation may affect a nerve-trunk in the neighbourhood of a suppurating wound; the nerve is swollen and congested, there infiltration of its connective tissue with inflammatory products, and the

fibres themselves may exhibit degenerative changes. In chronic inflammation we find an overgrowth of the connective tissue of the epineurium and perineurium; whilst in the later stages the areolar tissue in the fasciculi becomes affected, and degeneration of the nerve fibres occurs. These changes are well seen in Fig. 155, from a case in which Sands and Séguin, of New York, excised the cords of the brachial plexus. The changes of chronic traumatic neuritis tend slowly to ascend the nerve, and may even extend to the cord and give rise to sclerosis.

Symptoms.—The symptoms of traumatic neuritis are intense pain and tenderness in the line of the affected nerve. Sensation is variously modified in the parts supplied by the nerve; there may be numbness, or tingling, or anæsthesia; in other cases there may be intense neuralgic pain. Occasionally there are spasms, but more commonly there is weakness or paralysis of some of the muscles supplied. Poore has shown that in a considerable proportion of the cases which have come under his care for loss of writing-power, tenderness has been found in the course of some one or more of the nerves of the arm, and on tracing the history, the origin of the affection was frequently found to be a strain or other injury. In one case recorded by him, the whole brachial plexus in the axilla became intensely tender after a violent strain of the shoulder. The patient's sufferings were very great, and nothing gave him much relief. At last, after prolonged rest, the symptoms subsided, and it was then found that the serratus magnus was paralysed. Finally, this also recovered. In hysterical patients the symptoms are often greatly exaggerated.

Treatment.—In the early and painful stage of the disease, electricity aggravates the mischief. The tender nerves should be freely blistered, and the affected limb kept at perfect rest. When the symptoms are less intense a long strip of capsicum plaster applied along the line of the nerve gives much relief. If any constitutional condition such as gout, rheumatism, or syphilis can be detected, it must be treated by appropriate means. These cases are always chronic, often lasting many months before the symptoms disappear. In others, all milder means having failed, surgical operations of various kinds have been undertaken for the relief of the patient. These operations are of three kinds:—1. Excision of the bulbous ends of the nerves in cases of neuritis following amputation; 2. Division or excision of a portion of the affected nerve; and 3. Nerve-stretching.

1. **Excision of the Bulbous Ends of the Nerves.**—This has been undertaken usually under the impression that the bulbous end was the seat of the mischief. In some cases no doubt a painful stump is due to implication of the end of the nerve in the cicatrix, and then relief is given by the operation. If however the symptoms are due to true chronic ascending neuritis, this operation, although occasionally giving relief for a short time, is never productive of a cure.

2. **Division or excision of portions of the Nerve.**—The smaller nerves of the limbs have repeatedly been divided or partially excised, in cases of persistent traumatic neuralgia. The larger nervous trunks, such as the median, musculo-spiral, and ulnar, have been treated in the same way in the upper limb; and the external popliteal, and even the sciatic nerve in the lower limb, has been partially excised as a last resource in extreme cases. These operations have in some cases effected a permanent cure, in others they have been followed by only temporary relief.

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1. **Excision of the Bulbous Ends of the Nerves.**—This has been undertaken usually under the impression that the bulbous end was the seat of the mischief. In some cases no doubt a painful stump is due to implication of the end of the nerve in the cicatrix, and then relief is given by the operation. If however the symptoms are due to true chronic ascending neuritis, this operation, although occasionally giving relief for a short time, is never productive of a cure.

2. **Division or excision of portions of the Nerve.**—The smaller nerves of the limbs have repeatedly been divided or partially excised, in cases of persistent traumatic neuralgia. The larger nervous trunks, such as the median, musculo-spiral, and ulnar, have been treated in the same way in the upper limb; and the external popliteal, and even the sciatic nerve in the lower limb, has been partially excised as a last resource in extreme cases. These operations have in some cases effected a permanent cure, in others they have been followed by only temporary relief.

Sands, of New York, removed a section of the whole brachial plexus close to the exit of the nerves from the spinal column. This was done in a lad aged eighteen, whose right arm had been seriously injured in firing a salute. The arm was amputated, but the patient suffered the most agonizing torture from chronic nerve-lesion high up in the limb. So great were his sufferings that he became uncontrollable in his actions, and, although perfectly sane, gave way to fits of the most intense excitement. The operation consisted in making an incision along the outer border of the right sterno-mastoid, and a transverse one following the line of the clavicle. The ⅃-shaped flap was turned up, the carotid sheath and its contents carried to one side, and the brachial plexus

Fig. 155.—Section from Lower Cord of Brachial Plexus near Intervertebral Foramina, showing the lesions of Chronic Neuritis (Sands and Séguin).

a. Secondary fasciculi, showing atrophied fibres (circles not much larger, under 300 diam., than those of normal nerve under 65 diam.); very few axis-cylinders present. Tissue between fibres increased.
a'. Small aggregation of fibres, separated from others by overgrowth of endoneurium.
b. Hypertrophied perineurium and epineurium. Sheaths of fasciculi no longer distinct.
c. Dilated blood-vessels surrounded by altered connective tissue.
d. Yellow granular pigment lying in areolar tissue, mostly in neighbourhood of vessels.

exposed. Pieces fully a quarter of an inch in length were cut out from the four lower cervical and first dorsal nerves, and from one of these Fig. 155 was taken. Considerable relief from suffering followed the operation.

3. **Nerve-stretching.**—This operation was introduced by Nussbaum as a mode of treating intense neuralgia following injury. In a case of this kind affecting the arm, and resulting from gunshot injury, he cut down and stretched the ulnar nerve, then the nerves surrounding the brachial artery, and lastly, the brachial plexus itself. The result was a perfect cure. Since then the operation has been extensively practised.

Under the name of "nerve-stretching" two distinct operations are included. In operating on the larger trunks the nerve is exposed, cleanly isolated for an inch or more, and forcibly stretched either by passing the finger beneath it,

as in the case of the sciatic, or by means of a hook; but on account of the size and strength of the nerve its power of conduction is never completely destroyed, even if considerable force be used, although there may be some modification in its function. In operations on the smaller nerves, as the facial, the nerve is exposed and stretched with a hook, and it will always be found, if moderate force be used, that conducting power is as completely abolished as if the nerve had been divided. This operation is therefore equivalent to division, the only difference being that, as the continuity of the nerve is not destroyed, restoration of function is certain to take place sooner or later.

The most complete account of nerve-stretching in the English language is that given by Marshall in the Bradshaw Lecture delivered at the Royal College of Surgeons in 1883, to which the reader is referred for fuller information on the subject.

Nerves possess but slight extensibility and elasticity, but their cohesion or strength is very great. The breaking-strain of a nerve varies necessarily with its size. Thus that of the supra-orbital is said to be about six pounds, while a healthy sciatic will support 1·8 of the weight of the body, or in a healthy man about 270 lbs. When a nerve is steadily stretched longitudinally with moderate force, the strain is borne at first almost entirely by the fibrous tissue composing the sheath. The nerve-fibres are straightened and the spaces between them narrowed, and thus the vessels and lymph-spaces could be squeezed and emptied of their contents. When the strain is increased to about two-thirds of the breaking-strain and continued for some minutes, it comes to act more directly on the tubules, and produces very definite changes in their structure. The first effect observed is fissuring or cleavage of the medullary sheath. A still more forcible strain causes the medullary sheath to be broken up into irregular masses. If still greater force be applied the axis-cylinder and the tubular sheath may be ruptured. This degree of injury can hardly be inflicted in actual practice when stretching a large nerve by longitudinal traction with the finger and thumb. In stretching a nerve transversely with a hook the medullary sheaths are commonly ruptured and disintegrated at the point of pressure, and the axis-cylinder ruptured, the continuity of the nerve being thus practically interrupted.

The *rationale of the effects* of nerve-stretching for the relief of chronic neuritis was first suggested by Marshall. The fact that in neuritis the nerve itself is tender, and that, as a rule, the pain is not referred to the parts supplied by the affected nerve, led him to the conclusion that the nerve-trunks must contain sensory fibres distributed in their sheaths, or *nervi nervorum.* At the time this suggestion was made, although sympathetic fibres accompanying the vessels had been demonstrated in nerves by Sappey, no others had been recognised. Victor Horsley, following up Marshall's suggestion, has, however, clearly shown that short medullated fibres terminating in tactile corpuscles exist in the perineurium and epineurium of all nerves. The pain and tenderness in the nerves in neuritis may, therefore, be explained by the pressure upon those nervi nervorum by inflammatory exudations and new connective tissue. In stretching a nerve the strain is first borne by the sheath, and it is not until very considerable force is applied that the proper tubules of the nerve begin to suffer. It is easy to understand, therefore, how the nervi nervorum ramifying in the sheath may be strained or ruptured to such an extent as to destroy their conducting power, and thus render the nerve itself

insensible without abolishing the power of the nerve to transmit sensory and motor impulses through its proper tubules.

The *secondary effects of nerve-stretching* are the same as those of other injuries of nerves. If force sufficient to disintegrate the medullary sheath and to interrupt the conductivity of the nerve is used, the degenerative changes already described as occurring after section of a nerve take place.

The Operation of Nerve-Stretching.—The nerve is exposed by an incision parallel to its course, unless this would needlessly damage neighbouring parts. It must be separated cleanly from the fat and areolar tissue surrounding it for a sufficient distance, and then raised from its bed with a blunt hook or with the fore-finger. If the nerve be of sufficient size it is seized between the finger and thumb and steady traction made upon it, as much as possible in the direction of its course. It should be stretched both centrifugally and centripetally, and the traction should be maintained for about five minutes in each direction. In the case of a small nerve, such as one of the branches of the fifth or the facial, two hooks are passed beneath, which are then separated from each other with sufficient force thoroughly to stretch the trunk without actually tearing it across. The force to be used necessarily varies with the size of the nerve. The sciatic may safely be stretched with a force of thirty pounds, which is about as much as can be exerted when grasping the nerve between the finger and thumb. In a fresh dead body the head may be raised by a hook under the facial nerve without tearing it across, but a smaller degree of force must be used in operating on the living body. The Surgeon must use his judgment in the force he employs in stretching the various nerves. The after-treatment of the wound presents nothing peculiar, but every effort should be made to secure union by the first intention, otherwise the operation may serve as a starting-point for neuritis.

Bloodless nerve-stretching has been suggested in the case of the sciatic. This is done by flexing the thigh upon the abdomen while the knee is bent. The leg is then gradually but forciby extended. In this position the sciatic nerve is thoroughly put on the stretch.

Physiological Effects of Nerve-Stretching.—It may at once be stated that the effect of stretching a small nerve on a blunt hook, even if only a moderate degree of force be used, is completely to interrupt its physiological continuity, abolishing sensation or voluntary motion or both, according to the nature of the nerve, in the parts supplied by it. In the case of a larger nerve stretched between the finger and thumb, a slight stretching seems to increase its conducting power to sensory and motor impulses of all kinds. A stronger pull impairs the function of the sensory fibres, causing numbness, or even complete anæsthesia, and if still more force be used motor paralysis may be induced. There is no conclusive evidence that nerve-stretching, however forcible, produces any mechanical or functional effect on the nerve-centres.

Results.—Nerve-stretching has been employed in a great variety of diseases besides cases of true neuritis, and these will be referred to in subsequent chapters. Marshall gives a table of 512 cases, collected from various sources. In 154 of these the operation was performed for neuralgia of the upper or lower limb, and were probably cases of true nerve-stretching without interruption of the physiological continuity of the nerve. In 108 the operation resulted in a cure, in 26 it gave rise to permanent improvement, in 11 temporary relief, and in 9 it failed, and one of these terminated in the death

of the patient. Nerve-stretching seems, therefore, in these cases to be very successful, and as it is practically free from danger it should always be adopted when milder means have failed.

INJURIES OF MUSCLES AND TENDONS.

Contusions.—Muscles are frequently bruised by violent blows or falls, a few fibres being often ruptured. The chief signs of this injury are a sense of inability to use the muscles, and great pain on attempting to do so. There is tenderness on pressure over the bruised spot, but passive movements do not cause pain so long as they do not put the injured fibres on the stretch. By careful attention to these points, it is easy to distinguish these injuries from fractures of neighbouring bones, which they sometimes resemble—especially in the neighbourhood of the shoulder-joint.

Sprains or Strains of muscular parts, without rupture of fibres, are of very common occurrence, especially about the shoulder, the hip, and the loins, and are accompanied by much pain and stiffness, and by inability to move the part. When they occur in rheumatic subjects, these injuries not uncommonly give rise to severe and persistent symptoms; painful atrophy, rigidity, or local paralysis of the injured muscle being induced in some cases. It is then often difficult to determine how much is due to the direct strain of the muscle, and how much to chronic neuritis resulting from a simultaneous strain of the nerves. When complete atrophy of a muscle preceded by much pain follows a strain, it is probable that the nerves have been implicated in the injury.

In the **Treatment** of these accidents, when recent, it will be found that kneading or rubbing the part with a stimulating embrocation gives relief, but, if the pain be severe, the application of hot fomentations with rest is more effectual. In the later stages, blisters applied to the points at which the pain is most severely felt are often beneficial. If the injury occur in persons of a rheumatic diathesis, the effects are much more severe and persistent than in those who are otherwise constituted. In such persons, douches, frictions, and passive motion will, after a time, be necessary, together with proper constitutional treatment. In strumous subjects, a sprain may lead to the development of very serious inflammations.

Muscles that have been sprained sometimes undergo a species of rigid atrophy, with much impairment of motion of the limb or joint. In such cases, frictions, douches, and above all, electricity, will be found useful.

Rupture of the Sheath.—It occasionally happens that the sheath is ruptured, so that the belly of the muscle forms a kind of hernial protrusion through the aperture. This usually happens with the biceps, or the extensors of the fingers or the rectus femoris.

Dislocation or Displacement of Muscles or Tendons.—The long slender muscles of the forearm, and the complicated ones of the back with their innumerable tendons and bellies, and all tendons lying in grooves in bones, are liable to be displaced by some sudden and unusual movement. The accident is popularly spoken of as a "rick." The characteristic features of the accident are, that during some forcible movement the patient feels a sudden severe pain, localized to a single spot, and at the same time finds himself unable to execute certain movements. The Surgeon in the majority

of cases by careful examination and by noting exactly what movement causes the pain, will be able to ascertain which is the affected muscle. A displaced superficial tendon may be felt moving in its abnormal situation. Callender laid down the following rules for the treatment of this injury. First, guided by the pain, decide as to the muscle, or digitation of a muscle, which is probably the seat of the injury. Secondly, relax the muscle as far as possible by putting the part in the position which would be induced by its full contraction. Thirdly, by firm manipulation, such as by rubbing with the hand, or by kneading with the thumb, endeavour to replace it. Fourthly, if this fail, make pressure over the part whilst you make the patient contract the muscle, or if he cannot do this, put the part suddenly in such a position as to stretch the muscle. These manipulations must be done without an anæsthetic, as we need guidance from the sensations of the patient and the action of the affected muscle. Replacement is seldom possible after two or three weeks. If the condition is left unrelieved the parts seem to accommodate themselves to their new positions, and the pain subsides, but some permanent weakness may remain. The accident is always likely to recur, even if the displacement has been successfully reduced.

The following are the chief situations in which this accident has been met with :—

The **Long Tendon of the Biceps.** In a case of this kind described by Callender, there was great pain and inability to move the biceps or even the shoulder-joint. The shoulder seemed to droop forwards. The tendon could be felt lying at the inner side of its groove. It could be replaced, but no treatment would keep it in position. It is probable that some at least of the cases of so-called subluxation of the shoulder have been examples of this injury.

Various **Tendons at the Wrist** have been displaced. They are usually replaced without difficulty by the means above described. The parts must be kept fixed for about two weeks, by means of splints and properly arranged pads.

The **Small Muscles of the Back,** or of the back of the neck, are occasionally displaced. Replacement can best be effected by firm pressure over the painful spot, while the patient carries out the movement that gives him pain.

The **Tendon of the Peroneus Longus** may slip out of its sheath behind the outer ankle, which is torn in some violent twist of the foot inwards. The accident is liable to recur, and is often a source of much discomfort and temporary lameness. The treatment consists in the first instance of absolute fixation of the foot for some weeks in plaster bandages or splints, to give time for the sheath to consolidate. To prevent recurrence, a spring clip should be worn, so as to press the tendon against the fibula.

Rupture and Division.—Subcutaneous rupture of muscles and tendons not unfrequently occurs, not so much from any external violence as from the contraction of the muscle rupturing its own substance. The rupture may occur at one of four points: in the muscular substance itself; at the line of junction between the muscle and the tendon; through the tendon; and, lastly, at the point of insertion of the muscle or tendon into bone. Sédillot found that, in 21 cases, the rupture occurred at the point of origin of the tendon from the muscle 13 times; and in the remaining 8, the muscle itself was torn.

These ruptures most commonly occur in middle-aged or elderly men, who have lost the elasticity of youth, though their physical strength is unimpaired. At the moment of rupture, the patient usually experiences a sudden shock, as if he had received a blow, and sometimes hears a snap. He becomes unable to use the injured limb, and at the part where the rupture has occurred he finds a hollow or pit, produced by the retraction of the ends of the torn muscle, the belly of which contracts into a hard lump.

These accidents, though troublesome, are seldom serious. The tendo Achillis, the quadriceps extensor of the thigh, the triceps of the arm, the biceps, the deltoid, the rectus abdominis, are the tendons and muscles that most commonly give way, the relative frequency being indicated by the order in which they are here placed.

Muscles and tendons may be cut across accidentally or purposely in almost any part of the body. In these injuries there is always a considerable amount of gaping of the wound, owing to the retraction of both ends, if a muscle be divided, and of the muscular end only, if a muscle be separated from its tendon or the tendon cut across.

Union.—The mode of union of these injuries has been well described by Paget. When a tendon is cut across, the space between the ends is immediately filled by a blood-clot. Exudation rapidly follows from the vascular sheath and areolar tissue in the neighbourhood; the clot is penetrated by the wandering cells, and is soon decolorized and absorbed, till on the third day its place is occupied by a soft greyish-pink mass, extending also into the sheath and surrounding the cut ends of the tendon. This mass will be found to be composed of small round cells, with a homogeneous intercellular substance, mixed with which may here and there be seen some remains of the blood clot. New vessels penetrate it from without, and it afterwards undergoes the ordinary changes observed in the development of granulation-tissue into fibrous tissue. By experiments upon animals, Paget showed that by about the fourth or fifth day the bond of union has become more defined in outline, and forms a distinct cordlike mass between the ends of the tendon, and the microscope shows that the cells have lengthened out and become spindle-shaped, so that the tissue appears fibrillated; in the course of two or three more days it becomes tough and filamentous; after this the tissue gradually perfects itself, until it closely resembles normal tendon, though for some time it remains dull white and more cicatricial in appearance. The strength of this bond of union is marvellously great; Paget found that the tendo Achillis of a rabbit, six days after its division, required a weight of 20 lbs. to rupture it. In ten days the breaking weight was 56 lbs. Divided muscles unite in the same way as tendons but less quickly, and by a fibrous cicatrix; Weber, Gussenbauer and others have, however, recorded observations which tend to show that, under favourable conditions, gradual regeneration of muscular tissue may take place in the scar.

Treatment.—The principle of treatment in these cases when the injury is subcutaneous is extremely simple: it consists in relaxing the muscles by position, so as to approximate the divided ends; and in maintaining the limb in this position for a sufficient length of time for union to take place. If muscular relaxation be not attended to, the uniting bond will be elongated and weak, and perhaps altogether inefficient. Stiffness and weakness are often left for many months after union has taken place; very commonly,

of . . . 's sheath, and of the . . . touches, followed by . . . suppleness of the parts. . . atment, the adhesions . . . part under an anaesthetic. By . . . will be no fear of tearing these.

. . n wound must be treated by . . . antiseptic silk sutures may be used. . . should be closed over them, . . . lax the tendon, and every effort made . . . If suppuration takes place between . . . and of union, if any is developed, is a . . . ends form firm adhesions to the surround . . . wound, there is great risk of its . . . loose areolar tissue surrounding the . . . an accident which may be followed by slough . . . tendon, or at least by extensive and dense . . .

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INJURIES OF SPECIAL MUSCLES AND TENDONS.

When the **tendo Achillis** is ruptured, the best . . . treatment consists in the application of an apparatus formed of a dog-collar placed round the thigh above the knee, from which a strap is attached to a loop in the back of a slipper; by shortening this strap, the leg is bent on the thigh, and the foot extended, so that the muscles of the calf become completely relaxed (Fig. 15 . .). After this simple apparatus has been used for two or three weeks the patient may be allowed to go about, wearing a high-heeled shoe for some weeks longer.

Partial Rupture of the Muscles of the Calf.

This injury has received the name of *Lawn Tennis* . . . the frequency with which it occurs amongst middle-aged . . . during that game. It consists of a rupture of some of . . . the gastrocnemius, usually near their attachment to the tendon . . . feels a sudden pain, so that he may think he has been struck . . . ball, and finds he cannot use his leg. Sometimes a small . . . felt at the seat of the rupture. On the following day the calf is . . . discoloured by extravasated blood. The treatment recommended by Wharton Hood is to elevate the limb for a few minutes, and then to strap the leg in the same way as for a chronic ulcer. The strapping must not be . . . tightly applied at first. On the third day it may be removed and re-applied more firmly, and this must be repeated at intervals of two or three days for about two weeks. The patient may move about during the treatment, but must avoid violent exercise.

The **Quadriceps Extensor of the Thigh** may be torn away from its *insertion* into the patella, or the tendon of the rectus may be ruptured . . . *an inch* above this. Such an accident occurs in the same way that . . . *is broken* across, namely, by a violent muscular effort to prevent falling when *the knee* is semi-flexed. Under these circumstances one of three things . . .

iappen: the tendon of the rectus, the patella, or the ligamentum patellæ will give way. Most commonly the patella is broken across; next the tendon gives way, and least frequently the ligament. When the tendon gives way he patient falls on the ground, is unable to raise or stand on the injured imb, and a distinct gap occasioned by the retraction of the muscle can be felt above the patella between the fleshy masses of the vasti, which are very rarely orn. The accident is usually followed by some swelling of the joint. Owing o the distance to which the upper end of the torn tendon is retracted, union nay fail to take place, but even if this does occur, the attachments of the asti remaining intact, the patient suffers but little inconvenience.

The ligamentum patellæ is rarely ruptured, and in many apparent cases of his kind a more careful examination shows that a small fragment of the atella remains attached to the ligament, and that the injury is in reality a racture of the patella. In many recorded cases the ruptured ligament fails o unite, a wide gap being left, and the utility of the limb is seriously impaired.

The **Treatment** both of rupture of the tendon and of the ligament is the ame as that of fractured patella, viz. elevation of the limb, supported on a back plint in the extended position of an angle of about 135° with the body. This nust be continued for several weeks, when the patient may be allowed to get about with the joint protected by a knee-cap. In three or four cases of this ccident which I have seen, somewhat troublesome stiffness of the parts has ong been left. If the ruptured ligamentum patellæ fails to unite and a useess limb is left, the two ends may be exposed by a longitudinal incision, and utured together after having been freshened. Sands, of New York, has sucessfully performed this operation in a case which came under his care eight nonths after the accident. He used silver sutures, which were left in the vound. The ends of the ruptured ligament could be brought together only after several transverse incisions had been made subcutaneously in the quadriceps above the knee.

An accident well known to football players as "*the poop*" is most commonly caused by a blow on the front of the thigh. There is a feeling of helplessness n the limb, which soon passes off, so that the player can resume the game. Slight lameness follows, with localized tenderness in the extensor muscles of he knee. The treatment consists in strapping the part, and recovery is soon complete. The exact nature of the injury is doubtful, but probably some nuscular fibres are ruptured or a partial paralysis is produced by the blow.

Rider's Sprain may occur in two situations—in the adductors, and in the nternal rotators of the femur. It is more commonly met with in the adductors. It consists in a laceration of some of the muscular fibres or of the fascia covering the muscles. It is due to a violent or spasmodic contraction of these muscles when the rider is in danger of losing his seat. The pain is very great. The grip is lost, and the sufferer is unable to ride. When he internal rotators, or some of the capsular muscles of the hip-joint, are he seats of the sprain, the pain and disability are referred to the back of the rochanter.

The *treatment* consists in rest, and the use of a spica strap or bandage, vith a pad over the injured muscle, so as to compress it and control its action.

Laceration of the Rectus Abdominis Muscle may occur in the effects of childbirth, or from blows upon the abdominal wall; a ventral hernia being

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TUSIONS.—Muscles are frequently bruised by violent blows or falls, a res being often ruptured. The chief signs of this injury are a sense of ty to use the muscles, and great pain on attempting to do so. There erness on pressure over the bruised spot, but passive movements do not pain so long as they do not put the injured fibres on the stretch. By attention to these points, it is easy to distinguish these injuries from es of neighbouring bones, which they sometimes resemble—especially in ghbourhood of the shoulder-joint.

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LOCATION OR DISPLACEMENT OF MUSCLES OR TENDONS.—The long muscles of the forearm, and the complicated ones of the back with nnumerable tendons and bellies, and all tendons lying in grooves in are liable to be displaced by some sudden and unusual movement. The it is popularly spoken of as a "rick." The characteristic features of cident are, that during some forcible movement the patient feels a severe pain, localized to a single spot, and at the same time finds f unable to execute certain movements. The Surgeon in the majority

of cases by careful examination and by noting exactly what movement causes the pain, will be able to ascertain which is the affected muscle. A displaced superficial tendon may be felt moving in its abnormal situation. Callender laid down the following rules for the treatment of this injury. First, guided by the pain, decide as to the muscle, or digitation of a muscle, which is probably the seat of the injury. Secondly, relax the muscle as far as possible by putting the part in the position which would be induced by its full contraction. Thirdly, by firm manipulation, such as by rubbing with the hand, or by kneading with the thumb, endeavour to replace it. Fourthly, if this fail, make pressure over the part whilst you make the patient contract the muscle, or if he cannot do this, put the part suddenly in such a position as to stretch the muscle. These manipulations must be done without an anæsthetic, as we need guidance from the sensations of the patient and the action of the affected muscle. Replacement is seldom possible after two or three weeks. If the condition is left unrelieved the parts seem to accommodate themselves to their new positions, and the pain subsides, but some permanent weakness may remain. The accident is always likely to recur, even if the displacement has been successfully reduced.

The following are the chief situations in which this accident has been met with :—

The **Long Tendon of the Biceps.** In a case of this kind described by Callender, there was great pain and inability to move the biceps or even the shoulder-joint. The shoulder seemed to droop forwards. The tendon could be felt lying at the inner side of its groove. It could be replaced, but no treatment would keep it in position. It is probable that some at least of the cases of so-called subluxation of the shoulder have been examples of this injury.

Various **Tendons at the Wrist** have been displaced. They are usually replaced without difficulty by the means above described. The parts must be kept fixed for about two weeks, by means of splints and properly arranged pads.

The **Small Muscles of the Back,** or of the back of the neck, are occasionally displaced. Replacement can best be effected by firm pressure over the painful spot, while the patient carries out the movement that gives him pain.

The **Tendon of the Peroneus Longus** may slip out of its sheath behind the outer ankle, which is torn in some violent twist of the foot inwards. The accident is liable to recur, and is often a source of much discomfort and temporary lameness. The treatment consists in the first instance of absolute fixation of the foot for some weeks in plaster bandages or splints, to give time for the sheath to consolidate. To prevent recurrence, a spring clip should be worn, so as to press the tendon against the fibula.

Rupture and Division.—Subcutaneous rupture of muscles and tendons not unfrequently occurs, not so much from any external violence as from the contraction of the muscle rupturing its own substance. The rupture may occur at one of four points : in the muscular substance itself; at the line of junction between the muscle and the tendon; through the tendon; and, lastly, at the point of insertion of the muscle or tendon into bone. Sédillot found that, in 21 cases, the rupture occurred at the point of origin of the tendon from the muscle 13 times; and in the remaining 8, the muscle itself was torn.

the unaffected muscles of the limb, or from shortening of the paralyzed and atrophied muscles, should their points of attachment be approximated by the position in which the limb is placed.

The division of a purely *sensory nerve*, such as a branch of the fifth, completely abolishes sensation in the part supplied by it, but does not necessarily cause any serious disturbance of nutrition. This is probably due to the free communication between the various nerves of the face. Arloing and Tripier have shown by experiment that, after the division of a superficial sensory nerve, the neighbouring cutaneous nerves which communicate with the terminal branches of the one divided rapidly assume its functions so that sensibility may return in a few days without repair of the divided nerve. If the whole trunk of the fifth nerve is destroyed together with the Casserian ganglion, serious interference with nutrition follows, such as ulceration of the cornea or of the nasal mucous membrane. In central disease affecting the fifth nerve, the ganglion remaining intact, trophic changes do not occur, although, from loss of sensibility, the parts supplied by it are prone to suffer from injury. It may, in fact, be stated as a general rule that grave trophic changes do not occur unless a part is completely cut off from all communication with a healthy nerve-centre.

After the division of a *mixed nerve*, such as the ulnar, the nutrition of the part supplied by it is seriously modified. The muscles, as before stated, degenerate and waste. The whole part supplied by the injured nerve becomes congested, bluish, and, after a temporary rise of temperature in some cases, colder than natural. The fall of temperature is often very marked. Thus, I found in a woman who was under my care for a wound of the forearm, in which the ulnar nerve had been divided, that, twenty-one days after the injury, the temperature between the ring and the little finger of the injured side was 9° Fahr. below that of the same spot on the opposite hand. Sometimes the part becomes œdematous ; the skin often becomes rough and peels, but more commonly it is smooth, red and shining—the "glossy skin" of Paget; the nails grow badly, and are brittle or scaly, and abnormally curved longitudinally. Gradually increasing stiffness, with sometimes painful swelling, of one or more of the joints of the fingers may occur. Blebs, the contents of which become purulent, not uncommonly form on the tips of the fingers. Chilblains are readily produced by slight exposure to cold, and they frequently become vesicular or slough, leaving sluggish and unhealthy ulcers. Wounds in such parts heal badly, and are peculiarly prone to be affected by unhealthy spreading inflammations. If the patient be a growing child, the development of the affected part will be more or less completely arrested.

If union takes place between the opposite ends of the divided nerve, the various phenomena that have just been described gradually disappear, and complete restoration, first of sensation and afterwards of motion, with a return to the normal nutrition of the part, eventually takes place. Some voluntary motion usually returns in the muscles before electrical irritability is re-established. In many cases, however, especially if a piece of the nerve have been removed, or if the wound in which it has been divided heal by the second intention, recovery fails to take place. Under these circumstances, the central end becomes bulbous, just as in similar conditions in stumps, and it may then become the seat of intense neuralgic pains darting downwards to

owing to the adhesion of the divided tendon to its sheath, and of this to the neighbouring soft structures. Warm sea-water douches, followed by methodical friction, will greatly tend to restore the suppleness of the parts. If the stiffness does not readily yield to milder treatment, the adhesions must be broken down by forcible movement of the part under an anæsthetic. By the end of one month after the injury there will be no fear of tearing through the bond of union while so doing.

Tendons or muscles divided in an open wound must be treated by immediate suture. Either chromic catgut or antiseptic silk sutures may be used, the former being preferable; the wound should be closed over them, the limb placed in such a position as to relax the tendon, and every effort made to obtain union by the first intention. If suppuration takes place between the ends of a divided tendon, the bond of union, if any is developed, is almost always imperfect, and the divided ends form firm adhesions to the surrounding parts. Should pus form in the wound, there is great risk of its burrowing widely in the sheath, or in the loose areolar tissue surrounding the divided tendon, an accident which may be followed by sloughing of the tendon, or at least by extensive and dense adhesions.

Fig. 156.—Strap for Rupture of the tendo Achillis.

INJURIES OF SPECIAL MUSCLES AND TENDONS.—When the **tendo Achillis** is ruptured, the best mode of treatment consists in the application of an apparatus formed of a dog-collar placed round the thigh above the knee, from which a strap is attached to a loop in the back of a slipper; by shortening this strap, the leg is bent on the thigh, and the foot extended, so that the muscles of the calf become completely relaxed (Fig. 156). After this simple apparatus has been used for two or three weeks the patient may be allowed to go about, wearing a high-heeled shoe for some weeks longer.

Partial Rupture of the Muscles of the Calf.—This injury has received the name of *Lawn Tennis Leg*, from the frequency with which it occurs amongst middle-aged gentlemen during that game. It consists of a rupture of some of the fibres of the gastrocnemius, usually near their attachment to the tendon. The patient feels a sudden pain, so that he may think he has been struck with a ball, and finds he cannot use his leg. Sometimes a small sulcus may be felt at the seat of the rupture. On the following day the calf is more or less discoloured by extravasated blood. The treatment recommended by Wharton Hood is to elevate the limb for a few minutes, and then to strap the leg in the same way as for a chronic ulcer. The strapping must not be too tightly applied at first. On the third day it may be removed and re-applied more firmly, and this must be repeated at intervals of two or three days for about two weeks. The patient may move about during the treatment, but must avoid violent exercise.

The **Quadriceps Extensor of the Thigh** may be torn away from the insertion into the patella, or the tendon of the rectus may be ruptured about an inch above this. Such an accident occurs in the same way that a patella is broken across, namely, by a violent muscular effort to prevent falling whilst the knee is semi-flexed. Under these circumstances one of three things will

TREATMENT OF INJURIES CAUSING INTERRUPTION OF THE CONDUCTING POWER OF A NERVE.—The treatment of these injuries may be divided into two parts: 1st, the *Local treatment of the Injured nerve*, and 2ndly, *the Treatment of the Paralysed part.*

1. The **Local Treatment.**—In cases of *subcutaneous injury* nothing should be done, for it may be taken for granted that, although the nerve may be completely paralysed, its continuity is not destroyed. On dissecting limbs amputated for the most severe railway or machinery accidents, the nerves are almost invariably found untorn in the midst of the crushed tissues. To cut down, therefore, in a subcutaneous injury with the intention of suturing the nerve would be a grievous error. When the function of the nerve is abolished by *pressure*, the cause of pressure must be removed if possible, as by the cure of an aneurism, the excision of a tumour, or the reduction of a dislocation. When the cause of the paralysis is the *implication of the nerve in a cicatrix or in the callus of a fracture*, nothing should be done locally until, after waiting many months, it becomes evident that nature will not effect a cure. It will very rarely be found necessary in such cases to adopt any operative plan of treatment, the symptoms disappearing as the scar becomes looser with age, or as the provisional callus of the fracture is absorbed. Warren, however, relieved a case of neuralgia resulting from implication of a nerve in cicatricial tissue by dissecting it out without dividing or otherwise injuring it.

Primary Suture.—In cases of *division of a nerve in an open wound* no doubt exists as to the proper line of treatment: the two ends of the nerve should be found and carefully secured to each other by fine sutures. The best material for suture is very fine chromic catgut. Silk, which would not be absorbed for many weeks, might cause irritation and possibly severe neuralgia. The needle should be a common round sewing needle, which, if necessary, can be bent into a curve in the flame of a spirit-lamp and hardened again by being dipped in cold water; the ordinary flat surgical needle, with its cutting edges, needlessly damages the nerve. The end of the nerve should not be pinched with the forceps, as this may prevent rapid union. The sutures should be passed completely through the nerve, not through the sheath only, as this ensures better approximation of the ends. Three or four sutures having being applied, according to the size of the nerve, the wound must be closed and treated by some antiseptic method if possible; suppuration being usually fatal to success. The limb must be put in such a position as completely to relax the nerve. In a large proportion of the cases union will be obtained, with restoration of function.

The *prognosis* after primary nerve suture is good, but the period at which restoration of function may be expected varies greatly. Reference has already been made to these exceptional cases in which a rapid return of function has suggested the occurrence of primary union. Bowlby concludes from the consideration of a large number of cases that recovery may occur after weeks, months, or years; he finds that improvement usually begins within a year, but that a case cannot be looked upon as quite hopeless until the lapse of two or three years.

Secondary suture may be undertaken if the primary operation has failed, or if no attempt was made to suture the nerve at the time of the injury.

The operation is performed by freely exposing the nerve after rendering the limb bloodless. Its proximal extremity can sometimes be found by its bulbous

the consequence. Guthrie relates several remarkable cases occurring in military practice, of progressive atrophy of a part of the muscular wall of the abdomen following blows.

In **Rupture of the Muscles or Tendons of the Arms or Shoulder** support in a sling is all the special treatment needed. When the muscles about the shoulder are the seat of injury, rapid atrophy is apt to ensue, probably owing to the implication of the circumflex and suprascapular nerves, and consequent interference with the nutrition of the part. Fig. 157 is a good illustration of the remote effects of such a strain of the capsular muscles of the shoulder-joint. In this case the accident was caused by severe dragging upon the arm by the reins of a runaway horse.

Fig. 157.—Atrophy of Capsular Muscles of Shoulder.

In division of the **Extensor Tendons of the Fingers**—a very common accident—the tendons should, if possible, be united with catgut or tendon sutures, and the hand must be kept extended on a straight splint for three weeks until perfect union has taken place.

The **Flexor Tendons** of the hand may also be divided, either on the fingers or in the palm. In these cases the tendons should, if possible, be sutured, after which the fingers and wrist must be flexed and fixed on a suitable splint. Extensive retraction of the upper ends of the tendons often occurs, so that they can only be reached by carefully enlarging the wound upwards with strict antiseptic precautions.

Should the first operation fail, or should the division of the tendon have been overlooked at the time of the injury, secondary suture may be performed after the wound has healed.

In a case recorded by Mayo Robson, four and a half inches of the flexor tendon of a hopelessly smashed middle finger were successfully used to replace the tendon of the extensor indicis which had been torn away by the same injury.

CHAPTER XIX.

INJURIES OF BONES AND JOINTS.

INJURIES OF BONES.

A BONE may be bruised, bent, cut, or fractured.

Bruising of the Bone and Periosteum is usually of no great moment, but where the bone is but thinly covered, as at the shin or elbow, it may give rise to troublesome symptoms from inflammation of the periosteum, especially in gouty or syphilitic subjects. If the contusion be severe, the vitality of a layer of the bone may be destroyed, as happens sometimes from the graze or contusion of a bullet; whilst in certain cases a bruise of the bone is followed by acute suppuration beneath the periosteum or by tuberculous disease. In old people, the contusion of a bone may be followed by atrophy and shortening, as happens in the neck of the femur.

In the *Treatment* of bruised bone, immediate relief may be afforded by leeches, fomentations, or the application of warm lead and opium lotion. At a later period, and more especially if the pain be severe at night, iodide of potassium may be useful. In gouty subjects colchicum with salines will usually give relief. There is a very troublesome condition following a graze of the shin, with bruise of the periosteum and tibia, in which the slight abrasion does not heal readily, and the periosteum becomes thickened and pulpy. In these cases, rest of the limb, the application of lead lotion, the support of a bandage, and the administration of the iodide with bark, will be found to afford great relief. The consequences of bruise will be considered when we come to speak of necrosis.

Bending of Bone may occur in two conditions, viz. without or with fracture. Bending without fracture is met with in very young subjects, before the completion of ossification. When it takes place in adult life, it is the result of some structural change, by which the natural firmness of the osseous tissue is diminished. The bending most commonly occurs in the long or slender bones, especially the clavicle, the radius and the femur, but sometimes is met with in the flat bones, or those of the skull, in which depression takes place from a blow without fracture having occurred. In many cases of bending both of long and of flat bones, there is partial fracture on the convex side—the "green-stick fracture" (see p. 521).

The *Treatment* is simple: the Surgeon gradually straightens the bone, by applying a splint on its concave side, towards which the bone is pressed by a bandage and a pad applied upon its greatest convexity.

Fractures will be described in the two following chapters.

INJURIES OF JOINTS.

CONTUSIONS.—Joints are often *contused* by kicks, falls, or blows, so as to be severely injured, giving rise to much pain, and consequent inflammation of

the consequence. Guthrie relates several remarkable cases occurring in military practice, of progressive atrophy of a part of the muscular wall of the abdomen following blows.

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CONTUSIONS.—Joints are often *contused* by kicks, falls, or blows, so as to be severely injured, giving rise to much pain, and consecutive inflammation of

the capsule, synovial membrane, or other structures entering into their formation. As a result of contusion the joint may be suddenly distended with blood—**hæmarthrosis**. The blood so effused, mixed as it always is with much synovia, undergoes absorption after a time, without leading to any inconvenience.

The **Treatment** should consist of the application of a splint to ensure complete rest. An evaporating lotion or an ice-bag may be applied over the joint. Should the amount of effusion be very considerable, the tension and pain may be at once relieved by removing the blood by means of the aspirator. The needle must be washed through several times with a 1 in 20 solution of carbolic acid before being inserted, and care must be taken to keep it perfectly steady while it is in the joint.

In some cases a **bursa**, situated in the neighbourhood of a joint, is seriously bruised, and becomes inflamed: in consequence of which suppuration may follow. When this takes place, free incision into the inflamed part, with antiseptic treatment, will afford speedy and effectual relief.

SPRAINS.—When a joint is twisted violently so that its ligaments are either much stretched or partially torn across, though there be no displacement of the osseous surfaces, it is said to be *sprained*. These injuries are exceedingly painful and troublesome in their consequences. They most frequently occur at the wrist, knee, and ankle. The pain is very severe, and often sickening. Its intensity is very remarkable in view of the low degree of sensibility possessed by ligaments in the normal state. They may be cut without pain, but if stretched in a longitudinal direction or twisted, pain of the most intense character is at once set up—a wise provision of Nature guarding against articular displacements. At the time of the sprain a certain amount of blood is effused into the articular cavity and the surrounding tissues, in consequence of which the limb in a few days becomes discoloured for some distance above and below the joint. The sprain is rapidly followed by swelling and inflammation of the joint and investing tissues, often very chronic and tedious. As the inflammation subsides, stiffness and pain in using the part continue for a considerable length of time, and are in some cases followed by a kind of rigidity and wasting of the limb. In individuals of a rheumatic or gouty habit of body, the inflammation of the joint consequent on the sprain is often most tedious and chronic, and will yield only to appropriate constitutional treatment, whilst in strumous subjects tuberculous disease of the joint may follow.

Treatment.—If the sprain be slight, rubbing the part with a stimulating embrocation, and giving it the support of strapping or a bandage, are all that need be done. But if it be at all severe, more active measures must be had recourse to. These must vary according to the condition of the joint when the Surgeon sees the patient; but they are all based on the principle of securing perfect rest and subduing inflammation. In the vast majority of these injuries all that is necessary is to keep the part at rest for two weeks. The amount of discoloration that often follows a sprain is sufficient evidence of the extent of the laceration of the ligaments that has taken place. For the repair of this, rest is as necessary as for the healing of an open wound or the union of a broken bone. As a rule, however, unless the Surgeon makes it impossible, the patient, finding that he can still use the joint, although with some pain, continues to do so. This is the reason that sprains are so often

of the patient. Nerve-stretching seems, therefore, in these cases to be very successful, and as it is practically free from danger it should always be adopted when milder means have failed.

INJURIES OF MUSCLES AND TENDONS.

CONTUSIONS.—Muscles are frequently bruised by violent blows or falls, a few fibres being often ruptured. The chief signs of this injury are a sense of inability to use the muscles, and great pain on attempting to do so. There is tenderness on pressure over the bruised spot, but passive movements do not cause pain so long as they do not put the injured fibres on the stretch. By careful attention to these points, it is easy to distinguish these injuries from fractures of neighbouring bones, which they sometimes resemble—especially in the neighbourhood of the shoulder-joint.

SPRAINS or STRAINS of muscular parts, without rupture of fibres, are of very common occurrence, especially about the shoulder, the hip, and the loins, and are accompanied by much pain and stiffness, and by inability to move the part. When they occur in rheumatic subjects, these injuries not uncommonly give rise to severe and persistent symptoms; painful atrophy, rigidity, or local paralysis of the injured muscle being induced in some cases. It is then often difficult to determine how much is due to the direct strain of the muscle, and how much to chronic neuritis resulting from a simultaneous strain of the nerves. When complete atrophy of a muscle preceded by much pain follows a strain, it is probable that the nerves have been implicated in the injury.

In the **Treatment** of these accidents, when recent, it will be found that kneading or rubbing the part with a stimulating embrocation gives relief, but, if the pain be severe, the application of hot fomentations with rest is more effectual. In the later stages, blisters applied to the points at which the pain is most severely felt are often beneficial. If the injury occur in persons of a rheumatic diathesis, the effects are much more severe and persistent than in those who are otherwise constituted. In such persons, douches, frictions, and passive motion will, after a time, be necessary, together with proper constitutional treatment. In strumous subjects, a sprain may lead to the development of very serious inflammations.

Muscles that have been sprained sometimes undergo a species of rigid atrophy, with much impairment of motion of the limb or joint. In such cases, frictions, douches, and above all, electricity, will be found useful.

RUPTURE OF THE SHEATH.—It occasionally happens that the sheath is ruptured, so that the belly of the muscle forms a kind of hernial protrusion through the aperture. This usually happens with the biceps, or the extensors of the fingers or the rectus femoris.

DISLOCATION OR DISPLACEMENT OF MUSCLES OR TENDONS.—The long slender muscles of the forearm, and the complicated ones of the back with their innumerable tendons and bellies, and all tendons lying in grooves in bones, are liable to be displaced by some sudden and unusual movement. The accident is popularly spoken of as a "rick." The characteristic features of the accident are, that during some forcible movement the patient feels a sudden severe pain, localized to a single spot, and at the same time finds himself unable to execute certain movements. The Surgeon in the majority

case of sprain, and will be fully considered in the chapter on Diseases of Joints.

5. In severe sprains of joints, more especially of the knee, ankle, and shoulder, it often happens that there is *a slight displacement of the articular surfaces*. This may be directly occasioned by the violence that sprains the joint, or it may be secondary, coming on at a later period, owing to the constrained position in which the injured articulation has been kept for some length of time. If allowed to remain, it seriously interferes with the free mobility of the joint. In order that this be maintained, the most accurate coaptation of the articular surfaces is necessary. If there be the very slightest deviation from the accuracy of this "fit," they become locked in movement, and all motion becomes painful. This is especially the case in the hinge-joints, as the knee and elbow. In the ball and socket joints, more especially in the shoulder, the head of the humerus is apt to be thrown very slightly forwards on to the edge of the glenoid cavity, where it becomes fixed, all movements of the joint being exquisitely painful.

In all these cases of slight displacement connected with sprains that do not amount to dislocation, but where there is only a very slight want of true coaptation between the articular surfaces, the patient should be put under anæsthesia, and the joint "wrenched," so as to replace the bones and restore freedom and ease of movement.

So also, at a later period, when after a severe sprain, a stiff, painful, and possibly slightly distorted joint is left, no time should be lost in "wrenching" it. By this means, adhesions at this stage are broken down, and the proper "fit" of the bones restored. By neglecting this very simple treatment and leaving the joint but partially and only painfully mobile, the Surgeon is much discredited, and the patient drifting into the hands of the "bone-setter," has his limb "wrenched" into utility and ease by a most simple manœuvre.

Wounds of Joints.—A joint is known to be wounded when synovia escapes from the aperture or when the interior of the articulation is exposed. If there be any doubt as to the wound having penetrated the synovial membrane, no attempt should be made to ascertain this by probing, as in this way the very thing that is to be feared may be brought about by the Surgeon. If the wound be of sufficient size a careful and gentle examination may safely be made with the finger, after the hands have been carefully washed and disinfected. In all doubtful cases the wound must be treated as one of the joint, and the question whether it penetrated or not will often be cleared up by the symptoms that supervene.

Pathology.—In no class of injuries are the effects of the admission of air and of the consequent decomposition of the discharges more marked than in wounds of joints. The most extensive subcutaneous injuries of joints are recovered from, as a rule, without a serious symptom. Thus a simple dislocation of a large joint, although accompanied by laceration of the capsule, tearing of neighbouring muscles, and abundant extravasation of blood, is almost invariably recovered from with but little pain or inflammation, and with perfect restoration of mobility. On the other hand, a small incised wound, such as might be made by a stab with a pocket-knife, may be followed by the most severe constitutional symptoms and the most acute destructive inflammation of the joint, or, as it is called, **Traumatic Septic Arthritis.** The reason of this is not difficult to find. A joint consists in

most cases of an irregular cavity, capable of very considerable distension and very difficult to drain perfectly. A wound causes an effusion into the cavity, first of blood and, almost immediately after, of synovia, mixed with serous exudation from the vessels of the synovial membrane. The whole cavity thus becomes distended more or less tensely, according to the amount of drainage allowed by the wound, with putrescible matter, and this is brought into direct contact with the air by means of the external opening. The causes of decomposition thus being admitted, in the great majority of cases putrefaction follows, and the whole synovial membrane and the surfaces of the cartilages become bathed in septic fluid. As the result of this the most acute inflammation is set up, rapidly reaching the stage of suppuration. This soon extends to the *ligaments*, which become softened and yield, allowing the articular surfaces to become displaced; at the same time abscesses form outside the joint, either from perforation of the capsule or by extension of the inflammation through it; these may burrow widely beneath the muscles surrounding the joint. Within the joint the *cartilages* perish, in consequence of the irritation to which they are exposed; they become loosened from the subjacent bone, and by a process rather of maceration and friction than of true ulceration they become worn away at those points at which the articular surfaces have been most continuously in contact; the *bone* beneath is thus exposed, and from the combined irritation of the pressure of the opposed surfaces, a certain amount of friction, and the contact of the septic discharges, ulceration spreads rapidly into it. Thus the whole articulation becomes completely disorganized. This process is necessarily accompanied by very high fever. There is no surface in the body from which absorption takes place more rapidly than from the synovial membrane of a joint; as soon, therefore, as it becomes bathed in septic matter severe fever is developed, its intensity corresponding with the size of the joint and the extent of surface from which absorption is taking place. When the interior of the joint becomes covered by granulation-tissue, which presents a more or less efficient barrier to further absorption—that is to say, by about the eighth or tenth day—the fever subsides. Before this, however, the patient may perish from septic poisoning, or the case may become complicated by some infective process, as septic infection or pyæmia. The serious consequences, therefore, that follow wounds of joints may be traced entirely to the following causes: the accumulation of blood and serous effusion in the cavity of the joint, and the decomposition of the discharges, aggravated in some cases by want of rest and by the unhealthy constitutional condition of the patient and the bad hygienic surroundings in which he may be placed.

There are two ways, however, in which, without any special treatment, a wounded joint may escape the destructive processes above described: first, if the wound be very small and the instrument inflicting it perfectly clean, union of the external opening may take place by first intention, and the after-progress of the case may be the same as in a subcutaneous injury; secondly, if the wound be very large, so as to give perfect drainage to the cavity and thus to prevent the retention within it of decomposable matter, recovery may take place with comparatively little local inflammation or constitutional disturbance. It is a medium-sized wound, one too large or too contused to heal by the first intention and too small efficiently to drain the joint, that is the most dangerous. Wounds of joints, resulting from gun-shot injury, are necessarily the worst. In these, the aperture can rarely be closed

and united by the first intention; and the track of the ball must almost inevitably suppurate. The bones are also usually splintered, and foreign bodies of various kinds are introduced into the articulation, hence the most extensive and fatal mischief commonly ensues.

In a case of traumatic septic arthritis, if we have the opportunity of examining the joint, the appearances will vary with the time after the infliction of the injury. At the end of from twenty-four to forty-eight hours the synovial membrane will be found intensely red and injected, its surface lustreless, its fringes swollen; and the cavity will contain a quantity of turbid fluid still retaining some of the characters of synovia, but thinner than natural, in which microscopic examination would probably reveal the presence of micro-organisms. Later on, at the end of a week or ten days, the synovial membrane will have lost its characteristic appearance, being concealed by granulation-tissue, the surface of which is entirely or in part covered by a thin grey sloughing layer. The cartilages have lost their natural lustre and smoothness, their surfaces are yellowish in colour, and partial erosion will have commenced at the points at which the opposing articular surfaces have been in contact. The ligaments are swollen and softened, and the tissues surrounding the joint œdematous and infiltrated with inflammatory products. Such fluid as the joint contains will be thick pus. In the more advanced stages of the disease, when the joint has been suppurating perhaps for many weeks or even months, it will be found that it is difficult to recognize the synovial membrane, ligaments and capsule, all being lost in the mass of inflammatory products infiltrating their structures, giving them a uniform semi-transparent appearance. The cartilages are perforated in their central parts; at the circumference they have almost the appearance and feel of wet leather. The bones are exposed and are ulcerating superficially, the surface being rough and of a dark-red colour. Occasionally in the latest stages, if tolerable rest has been kept up in the treatment, granulations may have sprung up from the bony surfaces and have coalesced, and there may be some actual osseous union of the opposed surfaces. If recovery does take place in such a case it is effected by complete bony union between the opposing surfaces and gradual absorption of the inflammatory products and development of dense cicatricial tissue around the site of the joint. Microscopic examination shows nothing but the ordinary signs of inflammation in the various structures entering into the composition of the joint.

Symptoms and Effects.—The severity of the wound of a joint depends chiefly on the size of the articulation and the nature of the wound, but is also materially influenced by the age and health of the patient. Small subcutaneous wounds, such as are inflicted in the removal of loose cartilages, may usually be made with perfect safety, if proper antiseptic precautions be taken and the instruments be perfectly clean. But with joints laid open as the result of accidents, everything depends on the prevention of septic arthritis by the establishment of good drainage and the exclusion of the causes of decomposition. This latter condition may be difficult from the presence of dirt or foreign bodies in the cavity of the joint.

If the patient escapes the dangers of septic arthritis and the wound unites by the first intention, there is usually some effusion into its cavity, with heat and pain, which subside in a few days, leaving the articulation weak, tender, and stiff for some considerable time. This period of swelling is one of con-

siderable anxiety to the Surgeon, but if by the third day the symptoms begin to subside, and especially if there be no marked rise of temperature, he may confidently look forward to a speedy recovery. Should septic arthritis supervene, the joint within a few hours of the infliction of the injury, swells, becomes hot and painful, and throbs. The pain steadily increases, becoming tensive and excessively severe. If the aperture be large, synovia freely escapes, which soon becomes mixed with inflammatory products. If it be small, little more than a puncture, the joint swells and fills with pus, which will either escape through the original wound or find an outlet for itself, bursting through the capsule and burrowing widely beneath the fascia of the limb before reaching the surface. The swelling at first assumes the outline of the synovial membrane, but as soon as the inflammation has extended to the ligaments it becomes globular or oval. The skin over the joint becomes red and œdematous. The limb is instinctively placed in a position of semiflexion. There are startings in the limb, worse at night, waking the patient should he fall asleep. The pain becomes agonizing should the joint be moved in the slightest degree. The constitutional disturbance becomes very severe, the temperature often rising as high as 105° Fahr. The pulse is rapid and bounding, the tongue dry, the face flushed, and there is frequently delirium at night. The patient may succumb at this stage from the intensity of the septic fever. In other cases he may be early attacked by septicæmia or pyæmia.

If the patient survive this acute period, abscesses form around the articulation, and the discharge from these, as well as from the joint, with the chronic poisoning from absorption of the products of putrefaction, may gradually prove fatal by exhaustion. Should this danger be passed through and the patient eventually survive, it will be with an ankylosed limb, the utility of which is greatly impaired.

Treatment of Wounded Joints.—The first point to be determined must be whether amputation or resection should be performed, or an attempt made to save the injured joint. If the joint have been extensively laid open, with much contusion and laceration, complicated, perhaps, with dislocation or with fracture and splintering of the bones, no attempt to save the joint is likely to succeed. In these unfavourable circumstances, however, in the upper extremity, and even in the ankle, the limb may not unfrequently be preserved. If the bones be comminuted, the removal of splinters and resection of the articular ends may advantageously be practised in many cases, more particularly if the patient be young and sound in constitution and the soft parts not too extensively damaged. But, if these be largely lacerated and widely contused, or if the patient be aged or broken in health, amputation is imperatively called for. This is especially the case when the knee is injured; extensive lacerations of the joint, if complicated with dislocation, or with comminution of the bones, being cases for immediate amputation.

In all other cases an attempt should be made to save the joint. The prognosis in cases of wounded joints has been greatly improved, and the treatment simplified, by the employment of antiseptics and drainage. Indeed the surgery of joint wounds has been completely revolutionised, and cases that formerly would have been at once submitted to amputation are now saved without difficulty. This applies not only to incised wounds but equally to those of a lacerated character or that are complicated even with fracture of the articular ends.

If then it be determined to save the joint, three objects must be kept steadily in view: first, *the synovial cavity must be thoroughly drained*; secondly, *the joint must be kept perfectly at rest, and firmly fixed*; and thirdly, *the discharge must be prevented from decomposing by some efficient system of antiseptic treatment.* To drain a joint perfectly, as before stated, is not always easy, but every articulation can, without difficulty, be sufficiently drained to prevent the development of tension in its cavity. If an efficient system of antiseptic treatment can be carried out, minor imperfections of drainage are, however, of less consequence.

The Antiseptic Treatment of a wounded joint is carried out on exactly the same principles as that of any other wound. The wound must, if necessary, be enlarged; the cavity of the joint is then well syringed out with carbolic acid solution in water (1 to 20), perchloride of mercury (1 in 1000), or some other efficient antiseptic fluid. This is best done by means of a stiffish piece of india-rubber tubing long enough to reach to any part of the joint, fixed on the end of a syringe. The joint may be carefully moved at the same time, so that the lotion may find its way to every part of the articulation. The fluid is then squeezed out of the joint, and efficient drainage provided. This may be done by the use of drainage-tubes, or in many cases these may advantageously be dispensed with and the wound left freely open. If the case be one of a large lacerated wound, with dirt ground into it, it must be carefully cleaned with a sponge. If the wound is in such a situation that it is not likely to drain well, a counter-opening may be made on a probe at the most dependent part, into which another tube may be passed. The antiseptic dressing is then applied and the limb fixed on a splint or by some rigid apparatus in such a way that the slightest movement is impossible. If drainage-tubes have been used they can usually be removed at about the end of the first week, but this will depend upon the amount of discharge. Great care must be taken not to move the joint at the dressings.

One of the forms of absorbent antiseptic dressing, such as sublimate wood-wool, salicylic silk, salicylic or iodoform wool, &c., will be found most convenient in the treatment of wounded joints. The elastic pressure facilitates drainage and limits exudation, while at the same time it aids in maintaining rest. These may be applied as lasting dressings and left undisturbed, unless elevation of temperature, severe pain, or the appearance of discharge shows that all is not going on well. If drainage-tubes have been inserted, the dressing must be changed on the sixth or seventh day to remove them. After the first dressing, if all is going on well, the limb may be fixed in a plaster of Paris bandage, applied over the antiseptic dressing. If there is no elevation of temperature, and no pain, this may be left on till the wound is healed.

Should antiseptics not be available, the following treatment should be adopted. If the joint be opened by a puncture or small clean cut wound, this may occasionally be closed by bringing the edges together, and placing a piece of lint soaked in collodion upon it, or a strip of plaster washed over with resin varnish. The limb must then be placed in a splint (plaster of ris is the best), so as to be rendered absolutely immovable, and the joint ld be surrounded by india-rubber bags containing pounded ice, or cold by the application of Leiter's tubes (p. 214). In fact, the best ce of avoiding further mischief lies in the exclusion of air, perfect rest,

and the continuous application of dry cold. In this way inflammation may be prevented, and union of the wound take place under the plaster; but in the majority of cases the injury is followed by so abundant a secretion of synovia that the dressing becomes loosened by the tension and outward pressure of the accumulated fluid which escapes from under it. If, while the dressing remains adherent, the preventive means fail to arrest inflammation, and the joint swell, becoming red, hot, and throbbing, with some constitutional disturbance, the cold applications must be removed and heat substituted in the form of fomentations. The synovial cavity should then be emptied by means of the aspirator. If the fluid that is withdrawn be merely turbid synovia, the hot fomentations may be continued. Opium may be given to alleviate pain. In this way the symptoms may be relieved and the joint recover. Should the fluid withdrawn be pure pus, or contain a large proportion of pus, it is useless any longer to attempt the closure of the wound.

When suppuration has come on, long and free incisions should be made into the joint, on each side, if possible, and at the most dependent part of the capsule, so as to allow a ready exit to the pus. If this be done thoroughly, and perfect rest maintained afterwards, the symptoms are immediately relieved, and ultimately recovery may take place, usually with ankylosis, but occasionally with some degree of mobility. Small incisions into the joint are worse than useless; by a small incision the pus cannot be evacuated from a deep and complicated joint, but air is admitted, and the result is to favour the decomposition of the discharges, and to cause severe septic fever and possibly pyæmia; by making free and early incisions, however, and thus establishing perfect drainage, but little decomposable matter is left in the cavity of the joint, and the evils of decomposition are reduced to a minimum. The complete relief of tension effected by such incisions reduces the local inflammation and saves the patient much pain. After the incisions have been made, it is better to avoid poulticing or simple water-dressing, as these favour putrefaction. The wound must be syringed with some antiseptic solution, as Condy's fluid, carbolic lotion (1 in 40), perchloride of mercury (1 in 2000), or tincture of iodine and water (ʒij to Oj), and it must be dressed with carbolic oil (1 in 10), or terebene and oil (1 in 6), or a strong lead and spirit lotion. If boric acid lint be at hand, it forms a most efficient dressing, applied warm like a poultice and changed frequently. In the absence of all antiseptic material the open treatment, or the simple application of oil or lard, will be the best. If the case proceed favourably, the discharge will gradually lessen, and the constitutional disturbance subside. The joint must then be placed in such a position, that, when ankylosis results, the limb may be serviceable to the patient. If, however, as very frequently happens when the larger joints are wounded, the suppuration within the articulation, and the abscesses that form outside it, reduce the patient to a hectic state, secondary amputation speedily becomes inevitable.

Wounds of Individual Joints.—To the preceding general principles I have little to add with respect to wounds of individual joints.

The **Hip and Shoulder** are so deeply placed, and so well protected, that they can scarcely be wounded except as the result of gun-shot injury, the treatment of which has already been discussed (pp. 360, 366).

Wound of the **Knee-joint** is one of the most common and most severe of such injuries. Those caused by gun-shot violence have already been

described (p. 361). When produced by a puncture or a clean cut, antiseptic treatment and immobility will usually ensure a cure without the functions of the joint being in any way impaired. Thomas's knee-splint will be found the most convenient form of apparatus for fixing the joint. Should suppuration occur, the joint must be laid open unsparingly. The finger should be inserted at the original wound, if it be situated towards the front of the joint, and pushed down to the most dependent part of the synovial pouch; here the tip of the finger may be made to project and be cut down upon. A probe-pointed bistoury is then to be introduced and the incision extended till it reaches from the head of the tibia to the upper limit of the synovial pouch. The knife should be slanted backwards so as to facilitate drainage. The opposite side of the joint must then be treated in the same way. Even after this amputation may be necessary, and the incisions above described can be used in the operation. If the drainage is inefficient, abscesses will often form deeply, the pus bursting from the joint by the upper part of the synovial pouch, and burrowing up the thigh under the vasti, reaching sometimes as high as the trochanter before it is detected. At the time the synovial pouch gives way the relief of tension may cause a deceptive abatement in the severity of the symptoms; but soon the limb swells up to the trochanters, becomes tense, painful, hot, and œdematous, with great constitutional disturbance and high fever, though the joint may be but little swollen, and many days will often elapse before fluctuation can be again felt in it or in the thigh. This absence of swelling in the knee itself may mislead an inexperienced practitioner. At length the abscess may approach the surface near the knee; and, on an incision being made, an immense quantity of pus is discharged. It is the depth in the limb at which the abscess is seated that gives rise to the difficulty in its detection, the violent constitutional disturbance it occasions, and its extreme danger. I have never seen abscess form amongst the muscles of the leg as a consequence of injury of the knee-joint, unless the tibia had been fractured as well as the joint opened.

For the penetration of the knee-joint by needles, see p. 342.

Wounds of the **Elbow** and **Ankle-joints,** when simple, as in punctures, usually admit of closure and of being healed, leaving a sufficiently useful and mobile articulation. When they are complicated with fracture of the neighbouring bones, the soft parts not being too extensively injured, resection of the wounded articulations is the proper course to adopt; if there be much laceration of soft parts with comminution of the bones, amputation, especially in the case of the ankle, will be required.

Wounds of the **Wrist-joint** are peculiarly dangerous, on account of the extent and complexity of the synovial membrane that enters into its conformation. Should suppuration be set up, some of the carpal bones may necrose. In these circumstances, if the patient be in good health and not too old, excision of the joint will leave a very useful hand; when excision is not practicable, amputation must be performed, if possible, by a flap taken from the palm, only the diseased articular ends of the radius and ulna being removed. In some cases the patient may recover without operation, but a stiff and comparatively useless hand will generally be left.

Dislocations will be described in Chapter XXII.

CHAPTER XX.

FRACTURES.

A Fracture may be defined as a sudden and violent solution of continuity in a bone; but by the term "fracture" it is convenient to describe other lesions, which, strictly speaking, are not comprised in the definition. The displacement of an epiphysis from the shaft of a bone is not really a *fracture* but a *separation;* as is also the displacement of a costal cartilage from a rib.

Causes.—Fractures are almost invariably the result of local causes, but the liability to their occurrence is modified by certain predisposing circumstances.

Local Causes.—Fractures may be the result of external violence, or muscular action.

External violence may be applied in two ways: directly or indirectly.

The worst forms of fracture are occasioned by **direct external violence** crushing and splintering the bone, as by the passage of a heavy wheel or by a gun-shot injury. The fracture always occurs at the point to which the force is applied and is often complicated with considerable mischief to the soft parts.

Indirect violence may break a bone in two ways. One that is more commonly talked of than seen is by *contrecoup*, in which, when a blow is inflicted on one part, the shock that is communicated expends its violence on the opposite point, where the fracture consequently occurs. This form of injury has been described only in the bones of the head. (See Chap. XXIV.)

In the other form the bone is broken by being snapped, as it were, between a resisting medium at one end, and the weight of the body on the other. Thus, a person jumping from a height and alighting on his feet may break his legs by their being compressed between the weight of the body above and the ground below. The long bones are those which are most frequently fractured in this way; and the fracture occurs at the greatest convexity, or at their weakest point. When a person jumps from a carriage that is in motion, although the height of the fall be not great, yet its force is considerable, the feet coming violently to the ground and being suddenly fixed, while the body moves with the same velocity as that with which it was being carried onwards in the vehicle. Hence, fractures received in this way are usually severe, and often compound or comminuted.

Muscular action is not an unfrequent cause of fracture of bones into which powerful muscles are inserted; especially the patella, the olecranon process of the ulna and some of the bony prominences, such as the acromion, which are broken in the same way that a tendon is ruptured—by the violent contraction of the muscles attached to them tearing them asunder. It is not often that the long bones are so fractured; but the humerus has been broken by a person striking at but not hitting another, or by suddenly throwing out

the arm to seize something that was falling; and the clavicle has been fractured by a rider giving his horse a back-handed blow. In these cases, however, muscular action may not have been the sole cause, the weight of the limb also tending to fracture the bone. Muscular action also aids in the fracture of bones by indirect violence; thus we see that a sober man who makes a violent effort to save himself more often breaks a bone in a fall than a drunken man who falls like a log.

Predisposing Causes.—Some bones are especially liable to be broken in consequence of their *serving as points of support.* Thus, when a person falls upon the hand, the shock is transmitted from the wrist through the radius, humerus and clavicle, to the trunk; the radius and clavicle, being the weaker bones, are then especially liable to be fractured. So again, the *situation* of a bone, irrespectively of any other circumstance, may predispose it to fracture; the prominent position of the nasal bones, and the exposed situation of the acromion, render these parts peculiarly liable to injury. The *shape* of some bones disposes them to fracture; thus, a long bone is necessarily more readily broken than a short and thick one; hence the tibia and femur are more often fractured from falls on the feet than the os calcis. *Certain parts of bone* are more commonly fractured than others. Those parts especially into which powerful muscles are inserted, or that are in exposed situations and hence liable to injury, or have to receive the weight of the falling body, are often broken. Hence the clavicle, the olecranon, and the neck of the femur, are commonly fractured.

Age exercises considerable influence, not only on the general occurrence of fractures, but on the liability of certain bones to be broken. Fractures may occur even in intra-uterine life, and many cases have been recorded in which one or more bones have been broken in the fœtus by blows upon the abdomen of the mother during the later months of pregnancy. Intra-uterine fractures may also occur as a consequence of syphilis; thus Chaussier dissected a syphilitic fœtus that had 113 fractures and another with 43. Fractures may occur also during birth, most commonly of the humerus or femur but occasionally of the bones of the skull. These are usually the consequence of instrumental delivery. Some cases that have been described as congenital fractures appear to me rather to be instances of arrest of development or failure of union between the various parts of the bone. These show no disposition to union or the formation of callus and I have never seen any operation such as wiring, scraping, &c. undertaken for their cure with success.

In early age, as the bones are elastic and partly cartilaginous, fractures occur less readily than in advanced life when they have become brittle and earthy. In children fractures frequently occur at the line of junction of the shaft with the epiphysis where ossification has not as yet become perfect. This separation of the epiphysis occurs chiefly at the lower ends of the humerus and femur, sometimes in the radius and other long bones. As age advances, the compact tissue of the shaft becomes denser and harder, but the cancellous structure of the extremities more dilated and looser; hence fracture of the neck of the femur is especially common in old people. In young persons the bone is usually broken transversly, but fractures taking place at a more advanced period of life are generally oblique, and often comminuted; in adults they also more commonly extend into joints than when occurring in early age. In children, more than one half the fractures

occurring in the upper limb are of the clavicle; and in the lower limb, fracture of the shaft of the femur by indirect violence is of extremely common occurrence.

Sex indirectly influences the liability to fracture, men being more frequently exposed to the causes of this injury than women. In women, the bones that are most commonly fractured are the clavicle, the radius, the tibia, and the neck of the femur; in men, the shafts of the long bones, the cranium, and the pelvis.

From statistical tables of fractures of the upper limb given by Flower, it appears that below five years of age the liability of the two sexes to fracture is equal. After five, the males steadily increase in liability up to middle life. After forty-five, the number of fractures of the upper limb in females exceeds that in males, in consequence of the extreme frequency of fracture of the lower end of the radius in women above middle life.

Side of the Body.—From the statistics of Gurlt, Middeldorpf, Lente and others, it would appear that fractures occur with about equal frequency on the two sides of the body.

Time of Year.—The popular supposition that the bones are more brittle in winter, and hence break more readily than at other seasons, is altogether a mistake; though fractures may be common at this period of the year, from falls being more frequent during frosty weather.

Spontaneous Fractures are those which happen without any very distinct cause, or under the influence of violence that would usually be insufficient to produce such an injury. They arise from various pathological conditions, amongst which the following are the chief. *Atrophy of Bone* occurs naturally in old age, and is, as before stated, a powerful predisposing cause of fracture; but mere senile atrophy seldom reaches such a degree as to lead to spontaneous fracture. In the same way atrophy from want of use may render the bone brittle, so that a very small force may break it, as we occasionally see in attempted reduction of old dislocations. A much more important form of atrophy is that which accompanies certain forms of disease of the central nervous system, especially general paralysis of the insane. Bruns has collected the records of sixty cases of spontaneous fracture occurring in the insane, and amongst these were many instances of multiple fractures. In some of these cases the bones were found to be greatly atrophied, and in one they were easily cut with a knife. General paralysis is not unfrequently complicated by violent maniacal attacks, and in the necessary restraint at these times it has happened that one or more of the patient's bones have been broken although no undue force has been employed. These cases have more than once given rise to charges of cruelty or manslaughter against the keepers in lunatic asylums. Spontaneous fractures occurring in *locomotor ataxy* have been described by Charcot, Weir Mitchell and others. These, like the joint affections of this disease, appear usually to occur in the early stage, before the development of ataxic symptoms. *Mollities ossium* is, as will be seen when that disease is described, often associated with spontaneous fracture. *Rickets* is more often a cause of bending or partial fracture under considerable violence, but cannot be said to be a cause of true spontaneous fracture. *Scurvy* was said by the older writers to cause a general weakness of the bones, but later observations have not confirmed this. In children it is said to predispose to separation of the epiphyses. *Constitutional Syphilis* was formerly believed in some cases to cause a general

and united by the first intention; and the track of the ball must almost inevitably suppurate. The bones are also usually splintered, and foreign bodies of various kinds are introduced into the articulation, hence the most extensive and fatal mischief commonly ensues.

In a case of traumatic septic arthritis, if we have the opportunity of examining the joint, the appearances will vary with the time after the infliction of the injury. At the end of from twenty-four to forty-eight hours the synovial membrane will be found intensely red and injected, its surface lustreless, its fringes swollen; and the cavity will contain a quantity of turbid fluid still retaining some of the characters of synovia, but thinner than natural, in which microscopic examination would probably reveal the presence of micro-organisms. Later on, at the end of a week or ten days, the synovial membrane will have lost its characteristic appearance, being concealed by granulation-tissue, the surface of which is entirely or in part covered by a thin grey sloughing layer. The cartilages have lost their natural lustre and smoothness, their surfaces are yellowish in colour, and partial erosion will have commenced at the points at which the opposing articular surfaces have been in contact. The ligaments are swollen and softened, and the tissues surrounding the joint œdematous and infiltrated with inflammatory products. Such fluid as the joint contains will be thick pus. In the more advanced stages of the disease, when the joint has been suppurating perhaps for many weeks or even months, it will be found that it is difficult to recognize the synovial membrane, ligaments and capsule, all being lost in the mass of inflammatory products infiltrating their structures, giving them a uniform semi-transparent appearance. The cartilages are perforated in their central parts; at the circumference they have almost the appearance and feel of wet leather. The bones are exposed and are ulcerating superficially, the surface being rough and of a dark-red colour. Occasionally in the latest stages, if tolerable rest has been kept up in the treatment, granulations may have sprung up from the bony surfaces and have coalesced, and there may be some actual osseous union of the opposed surfaces. If recovery does take place in such a case it is effected by complete bony union between the opposing surfaces and gradual absorption of the inflammatory products and development of dense cicatricial tissue around the site of the joint. Microscopic examination shows nothing but the ordinary signs of inflammation in the various structures entering into the composition of the joint.

Symptoms and Effects.—The severity of the wound of a joint depends chiefly on the size of the articulation and the nature of the wound, but is also materially influenced by the age and health of the patient. Small subcutaneous wounds, such as are inflicted in the removal of loose cartilages, may usually be made with perfect safety, if proper antiseptic precautions be taken and the instruments be perfectly clean. But with joints laid open as the result of accidents, everything depends on the prevention of septic arthritis by the establishment of good drainage and the exclusion of the causes of decomposition. This latter condition may be difficult from the presence of dirt or foreign bodies in the cavity of the joint.

If the patient escapes the dangers of septic arthritis and the wound unites by the first intention, there is usually some effusion into its cavity, with heat and pain, which subside in a few days, leaving the articulation weak, tender, and stiff for some considerable time. This period of swelling is one of con-

siderable anxiety to the Surgeon, but if by the third day the symptoms begin to subside, and especially if there be no marked rise of temperature, he may confidently look forward to a speedy recovery. Should septic arthritis supervene, the joint within a few hours of the infliction of the injury, swells, becomes hot and painful, and throbs. The pain steadily increases, becoming tensive and excessively severe. If the aperture be large, synovia freely escapes, which soon becomes mixed with inflammatory products. If it be small, little more than a puncture, the joint swells and fills with pus, which will either escape through the original wound or find an outlet for itself, bursting through the capsule and burrowing widely beneath the fascia of the limb before reaching the surface. The swelling at first assumes the outline of the synovial membrane, but as soon as the inflammation has extended to the ligaments it becomes globular or oval. The skin over the joint becomes red and œdematous. The limb is instinctively placed in a position of semiflexion. There are startings in the limb, worse at night, waking the patient should he fall asleep. The pain becomes agonizing should the joint be moved in the slightest degree. The constitutional disturbance becomes very severe, the temperature often rising as high as 105° Fahr. The pulse is rapid and bounding, the tongue dry, the face flushed, and there is frequently delirium at night. The patient may succumb at this stage from the intensity of the septic fever. In other cases he may be early attacked by septicæmia or pyæmia.

If the patient survive this acute period, abscesses form around the articulation, and the discharge from these, as well as from the joint, with the chronic poisoning from absorption of the products of putrefaction, may gradually prove fatal by exhaustion. Should this danger be passed through and the patient eventually survive, it will be with an ankylosed limb, the utility of which is greatly impaired.

Treatment of Wounded Joints.—The first point to be determined must be whether amputation or resection should be performed, or an attempt made to save the injured joint. If the joint have been extensively laid open, with much contusion and laceration, complicated, perhaps, with dislocation or with fracture and splintering of the bones, no attempt to save the joint is likely to succeed. In these unfavourable circumstances, however, in the upper extremity, and even in the ankle, the limb may not unfrequently be preserved. If the bones be comminuted, the removal of splinters and resection of the articular ends may advantageously be practised in many cases, more particularly if the patient be young and sound in constitution and the soft parts not too extensively damaged. But, if these be largely lacerated and widely contused, or if the patient be aged or broken in health, amputation is imperatively called for. This is especially the case when the knee is injured; extensive lacerations of the joint, if complicated with dislocation, or with comminution of the bones, being cases for immediate amputation.

In all other cases an attempt should be made to save the joint. The prognosis in cases of wounded joints has been greatly improved, and the treatment simplified, by the employment of antiseptics and drainage. Indeed the surgery of joint wounds has been completely revolutionised, and cases that formerly would have been at once submitted to amputation are now saved without difficulty. This applies not only to incised wounds but equally to those of a lacerated character or that are complicated even with fracture of the articular ends.

If then it be determined to save the joint, three objects must be kept steadily in view: first, *the synovial cavity must be thoroughly drained*; secondly, *the joint must be kept perfectly at rest, and firmly fixed*; and thirdly, the *discharges must be prevented from decomposing by some efficient system of antiseptic treatment*. To drain a joint perfectly, as before stated, is not always easy, but every articulation can, without difficulty, be sufficiently drained to prevent the development of tension in its cavity. If an efficient system of antiseptic treatment can be carried out, minor imperfections of drainage are, however, of less consequence.

The Antiseptic Treatment of a wounded joint is carried out on exactly the same principles as that of any other wound. The wound must, if necessary, be enlarged; the cavity of the joint is then well syringed out with carbolic acid solution in water (1 to 20), perchloride of mercury (1 in 1000), or some other efficient antiseptic fluid. This is best done by means of a stiffish piece of india-rubber tubing long enough to reach to any part of the joint, fixed on the end of a syringe. The joint may be carefully moved at the same time, so that the lotion may find its way to every part of the articulation. The fluid is then squeezed out of the joint, and efficient drainage provided. This may be done by the use of drainage-tubes, or in many cases these may advantageously be dispensed with and the wound left freely open. If the case be one of a large lacerated wound, with dirt ground into it, it must be carefully cleaned with a sponge. If the wound is in such a situation that it is not likely to drain well, a counter-opening may be made on a probe at the most dependent part, into which another tube may be passed. The antiseptic dressing is then applied and the limb fixed on a splint or by some rigid apparatus in such a way that the slightest movement is impossible. If drainage-tubes have been used they can usually be removed at about the end of the first week, but this will depend upon the amount of discharge. Great care must be taken not to move the joint at the dressings.

One of the forms of absorbent antiseptic dressing, such as sublimate wood-wool, salicylic silk, salicylic or iodoform wool, &c., will be found most convenient in the treatment of wounded joints. The elastic pressure facilitates drainage and limits exudation, while at the same time it aids in maintaining rest. These may be applied as lasting dressings and left undisturbed, unless elevation of temperature, severe pain, or the appearance of discharge shows that all is not going on well. If drainage-tubes have been inserted, the dressing must be changed on the sixth or seventh day to remove them. After the first dressing, if all is going on well, the limb may be fixed in a plaster of Paris bandage, applied over the antiseptic dressing. If there is no elevation of temperature, and no pain, this may be left on till the wound is healed.

Should antiseptics not be available, the following treatment should be adopted. If the joint be opened by a puncture or small clean cut wound, this may occasionally be closed by bringing the edges together, and placing a piece of lint soaked in collodion upon it, or a strip of plaster washed over with resin varnish. The limb must then be placed in a splint (plaster of Paris is the best), so as to be rendered absolutely immovable, and the joint should be surrounded by india-rubber bags containing pounded ice, or kept cold by the application of Leiter's tubes (p. 214). In fact, the best chance of avoiding further mischief lies in the exclusion of air, perfect rest,

and the continuous application of dry cold. In this way inflammation may be prevented, and union of the wound take place under the plaster; but in the majority of cases the injury is followed by so abundant a secretion of synovia that the dressing becomes loosened by the tension and outward pressure of the accumulated fluid which escapes from under it. If, while the dressing remains adherent, the preventive means fail to arrest inflammation, and the joint swell, becoming red, hot, and throbbing, with some constitutional disturbance, the cold applications must be removed and heat substituted in the form of fomentations. The synovial cavity should then be emptied by means of the aspirator. If the fluid that is withdrawn be merely turbid synovia, the hot fomentations may be continued. Opium may be given to alleviate pain. In this way the symptoms may be relieved and the joint recover. Should the fluid withdrawn be pure pus, or contain a large proportion of pus, it is useless any longer to attempt the closure of the wound.

When suppuration has come on, long and free incisions should be made into the joint, on each side, if possible, and at the most dependent part of the capsule, so as to allow a ready exit to the pus. If this be done thoroughly, and perfect rest maintained afterwards, the symptoms are immediately relieved, and ultimately recovery may take place, usually with ankylosis, but occasionally with some degree of mobility. Small incisions into the joint are worse than useless; by a small incision the pus cannot be evacuated from a deep and complicated joint, but air is admitted, and the result is to favour the decomposition of the discharges, and to cause severe septic fever and possibly pyæmia; by making free and early incisions, however, and thus establishing perfect drainage, but little decomposable matter is left in the cavity of the joint, and the evils of decomposition are reduced to a minimum. The complete relief of tension effected by such incisions reduces the local inflammation and saves the patient much pain. After the incisions have been made, it is better to avoid poulticing or simple water-dressing, as these favour putrefaction. The wound must be syringed with some antiseptic solution, as Condy's fluid, carbolic lotion (1 in 40), perchloride of mercury (1 in 2000), or tincture of iodine and water (ʒij to Oj), and it must be dressed with carbolic oil (1 in 10), or terebene and oil (1 in 6), or a strong lead and spirit lotion. If boric acid lint be at hand, it forms a most efficient dressing, applied warm like a poultice and changed frequently. In the absence of all antiseptic material the open treatment, or the simple application of oil or lard, will be the best. If the case proceed favourably, the discharge will gradually lessen, and the constitutional disturbance subside. The joint must then be placed in such a position, that, when ankylosis results, the limb may be serviceable to the patient. If, however, as very frequently happens when the larger joints are wounded, the suppuration within the articulation, and the abscesses that form outside it, reduce the patient to a hectic state, secondary amputation speedily becomes inevitable.

Wounds of Individual Joints.—To the preceding general principles I have little to add with respect to wounds of individual joints.

The **Hip and Shoulder** are so deeply placed, and so well protected, that they can scarcely be wounded except as the result of gun-shot injury, the treatment of which has already been discussed (pp. 360, 366).

Wound of the **Knee-joint** is one of the most common and most severe of such injuries. Those caused by gun-shot violence have already been

described (p. 361). When produced by a puncture or a clean cut, antiseptic treatment and immobility will usually ensure a cure without the functions of the joint being in any way impaired. Thomas's knee-splint will be found the most convenient form of apparatus for fixing the joint. Should suppuration occur, the joint must be laid open unsparingly. The finger should be inserted at the original wound, if it be situated towards the front of the joint, and pushed down to the most dependent part of the synovial pouch: here the tip of the finger may be made to project and be cut down upon. A probe-pointed bistoury is then to be introduced and the incision extended till it reaches from the head of the tibia to the upper limit of the synovial pouch. The knife should be slanted backwards so as to facilitate drainage. The opposite side of the joint must then be treated in the same way. Even after this amputation may be necessary, and the incisions above described can be used in the operation. If the drainage is inefficient, abscesses will often form deeply, the pus bursting from the joint by the upper part of the synovial pouch, and burrowing up the thigh under the vasti, reaching sometimes as high as the trochanter before it is detected. At the time the synovial pouch gives way the relief of tension may cause a deceptive abatement in the severity of the symptoms; but soon the limb swells up to the trochanters, becomes tense, painful, hot, and œdematous, with great constitutional disturbance and high fever, though the joint may be but little swollen, and many days will often elapse before fluctuation can be again felt in it or in the thigh. This absence of swelling in the knee itself may mislead an inexperienced practitioner. At length the abscess may approach the surface near the knee: and, on an incision being made, an immense quantity of pus is discharged. It is the depth in the limb at which the abscess is seated that gives rise to the difficulty in its detection, the violent constitutional disturbance it occasions, and its extreme danger. I have never seen abscess form amongst the muscles of the leg as a consequence of injury of the knee-joint, unless the tibia had been fractured as well as the joint opened.

For the penetration of the knee-joint by needles, see p. 342.

Wounds of the **Elbow** and **Ankle-joints,** when simple, as in punctures, usually admit of closure and of being healed, leaving a sufficiently useful and mobile articulation. When they are complicated with fracture of the neighbouring bones, the soft parts not being too extensively injured, resection of the wounded articulations is the proper course to adopt; if there be much laceration of soft parts with comminution of the bones, amputation, especially in the case of the ankle, will be required.

Wounds of the **Wrist-joint** are peculiarly dangerous, on account of the extent and complexity of the synovial membrane that enters into its conformation. Should suppuration be set up, some of the carpal bones may necrose. In these circumstances, if the patient be in good health and not too old, excision of the joint will leave a very useful hand; when excision is not practicable, amputation must be performed, if possible, by a flap taken from the palm, only the diseased articular ends of the radius and ulna being removed. In some cases the patient may recover without operation, but a stiff and comparatively useless hand will generally be left.

Dislocations will be described in Chapter XXII.

CHAPTER XX.

FRACTURES.

A FRACTURE may be defined as a sudden and violent solution of continuity in a bone; but by the term "fracture" it is convenient to describe other lesions, which, strictly speaking, are not comprised in the definition. The displacement of an epiphysis from the shaft of a bone is not really a *fracture* but a *separation;* as is also the displacement of a costal cartilage from a rib.

CAUSES.—Fractures are almost invariably the result of local causes, but the liability to their occurrence is modified by certain predisposing circumstances.

Local Causes.—Fractures may be the result of external violence, or muscular action.

External violence may be applied in two ways: directly or indirectly.

The worst forms of fracture are occasioned by **direct external violence** crushing and splintering the bone, as by the passage of a heavy wheel or by a gun-shot injury. The fracture always occurs at the point to which the force is applied and is often complicated with considerable mischief to the soft parts.

Indirect violence may break a bone in two ways. One that is more commonly talked of than seen is by *contrecoup*, in which, when a blow is inflicted on one part, the shock that is communicated expends its violence on the opposite point, where the fracture consequently occurs. This form of injury has been described only in the bones of the head. (See Chap. XXIV.)

In the other form the bone is broken by being snapped, as it were, between a resisting medium at one end, and the weight of the body on the other. Thus, a person jumping from a height and alighting on his feet may break his legs by their being compressed between the weight of the body above and the ground below. The long bones are those which are most frequently fractured in this way; and the fracture occurs at the greatest convexity, or at their weakest point. When a person jumps from a carriage that is in motion, although the height of the fall be not great, yet its force is considerable, the feet coming violently to the ground and being suddenly fixed, while the body moves with the same velocity as that with which it was being carried onwards in the vehicle. Hence, fractures received in this way are usually severe, and often compound or comminuted.

Muscular action is not an unfrequent cause of fracture of bones into which powerful muscles are inserted; especially the patella, the olecranon process of the ulna and some of the bony prominences, such as the acromion, which are broken in the same way that a tendon is ruptured—by the violent contraction of the muscles attached to them tearing them asunder. It is not often that the long bones are so fractured; but the humerus has been broken by a person striking at but not hitting another, or by suddenly throwing out

at the point of fracture, are more or less extensively lacerated; the periosteum is as a rule completely torn through, and separated from the broken ends for a short distance on one or both sides, leaving a ragged edge. In some cases the periosteum on one side may be intact, and it is said to have been found untorn even in complete fractures. As a rule it remains uninjured over a simple fissure. Blood will be found extravasated also in the medullary canal mixed up with the fat.

The *Period of Inflammation and Exudation.*—The first changes observed after the injury are the ordinary signs of inflammation—hyperæmia, swelling, and abundant exudation. This affects the whole of the injured soft parts, so that by the third or fourth day the fracture will be found to be surrounded by a greyish-red, soft mass, not sharply defined, but infiltrating the neighbouring tissues; the torn ends of the muscles are pale in colour from the exudation between the fibres; the areolar tissue is no longer clearly recognizable, its spaces being filled by the coagulated inflammatory exudation; the outer layer of the periosteum is in like manner swollen and scarcely recognizable, and the inner layer is so soft and swollen as to be almost gelatinous; the whole membrane can be stripped from the bone with unnatural ease for some distance from the seat of fracture. In the midst of the exudation, patches of unaltered blood-clot will still be seen, but a great part of the extravasation in the immediate neighbourhood of the fracture will have already been partly discoloured.

Microscopic examination at this stage shows the usual appearances of inflammation; the vessels are distended with blood, and all the spaces of the tissues are filled with wandering white corpuscles, either closely in contact with each other, or separated by a small quantity of homogeneous or fibrinous intercellular substance.

In the medulla the fat has disappeared from the immediate neighbourhood of the injury, and its place is taken by an exudation similar to that lying externally.

The growth of the soft provisional callus.—During this stage the excess of the inflammatory exudation and the remainder of the blood-clot in the neighbourhood of the injury are absorbed, and there is gradually developed round the ends of the broken bone a fusiform mass, holding them together with some degree of firmness. At first this is soft, almost jelly-like, and homogeneous in appearance, and the ends of the torn periosteum become lost in it. This soft provisional callus presents under the microscope the ordinary appearances of granulation tissue, but close to the bone many cells are found of larger size than the rest, and having one or more nuclei surrounded by a finely granular protoplasm. These *osteoblasts* are usually oval or spindle-shaped, or sometimes angular in form. They play, as we shall see, a most important part in the process of repair, and probably take their origin in the deeper layers of the swollen periosteum.

The callus next increases in density, and the superficial part undergoes the ordinary changes of the conversion of granulation tissue into fibrous tissue, thus forming the fibrous part of the new periosteum covering the callus. The changes which occur in the deeper parts of the provisional callus differ according to its situation. They are thus described by Bruns. In the part distant from the line of the fracture, lime salts are deposited in the form of trabeculæ in the intercellular ground-substance. These trabeculæ

occurring in the upper limb are of the clavicle; and in the lower limb, fracture of the shaft of the femur by indirect violence is of extremely common occurrence.

Sex indirectly influences the liability to fracture, men being more frequently exposed to the causes of this injury than women. In women, the bones that are most commonly fractured are the clavicle, the radius, the tibia, and the neck of the femur; in men, the shafts of the long bones, the cranium, and the pelvis.

From statistical tables of fractures of the upper limb given by Flower, it appears that below five years of age the liability of the two sexes to fracture is equal. After five, the males steadily increase in liability up to middle life. After forty-five, the number of fractures of the upper limb in females exceeds that in males, in consequence of the extreme frequency of fracture of the lower end of the radius in women above middle life.

Side of the Body.—From the statistics of Gurlt, Middeldorpf, Lente and others, it would appear that fractures occur with about equal frequency on the two sides of the body.

Time of Year.—The popular supposition that the bones are more brittle in winter, and hence break more readily than at other seasons, is altogether a mistake; though fractures may be common at this period of the year, from falls being more frequent during frosty weather.

Spontaneous Fractures are those which happen without any very distinct cause, or under the influence of violence that would usually be insufficient to produce such an injury. They arise from various pathological conditions, amongst which the following are the chief. *Atrophy of Bone* occurs naturally in old age, and is, as before stated, a powerful predisposing cause of fracture; but mere senile atrophy seldom reaches such a degree as to lead to spontaneous fracture. In the same way atrophy from want of use may render the bone brittle, so that a very small force may break it, as we occasionally see in attempted reduction of old dislocations. A much more important form of atrophy is that which accompanies certain forms of disease of the central nervous system, especially general paralysis of the insane. Bruns has collected the records of sixty cases of spontaneous fracture occurring in the insane, and amongst these were many instances of multiple fractures. In some of these cases the bones were found to be greatly atrophied, and in one they were easily cut with a knife. General paralysis is not unfrequently complicated by violent maniacal attacks, and in the necessary restraint at these times it has happened that one or more of the patient's bones have been broken although no undue force has been employed. These cases have more than once given rise to charges of cruelty or manslaughter against the keepers in lunatic asylums. Spontaneous fractures occurring in *locomotor ataxy* have been described by Charcot, Weir Mitchell and others. These, like the joint affections of this disease, appear usually to occur in the early stage, before the development of ataxic symptoms. *Mollities ossium* is, as will be seen when that disease is described, often associated with spontaneous fracture. *Rickets* is more often a cause of bending or partial fracture under considerable violence, but cannot be said to be a cause of true spontaneous fracture. *Scurvy* was said by the older writers to cause a general weakness of the bones, but later observations have not confirmed this. In children it is said to predispose to separation of the epiphyses. *Constitutional Syphilis* was formerly believed in some cases to cause a general

brittleness of the osseous system, but there is no evidence in proof of this; in every case in which syphilis is a cause of spontaneous fracture some definite local disease, as caries, necrosis, or a gumma, is met with. In the same way the "*cancerous cachexia*," apart from the development of a secondary tumour in the bone, never causes spontaneous fracture. A *sarcoma* growing in or on a bone, or pressing on it when springing from a neighbouring structure, may so weaken it as to cause it to give way. *Hydatid cysts of bone* are extremely rare in this country, but a few cases have been recorded in which they were a cause of spontaneous fracture. *Necrosis, caries and abscess of bone* have all been known to give rise to fracture, but such a complication is very uncommon. Some rare cases have been described in which there is a *hereditary tendency* to fracture of the bones, transmitted from father to son, without any other recognisable constitutional defect. Thus Greenish records a case in which the grandfather had had several bones broken; of his three sons and two daughters, the youngest son and the two daughters escaped without fractures; the eldest son, who had one bone broken, had two children, the eldest of whom had thirteen, and the younger two, fractures; the second son, who had two fractures, had five children, who suffered respectively four, four, eight, four, and three broken bones. Lastly, certain cases are met with in which no clear causes can be found: thus fracture of the femur has more than once been met with in young men apparently quite healthy, from the sudden and violent contraction of the thigh muscles, as for instance in pulling off or drawing on a boot, and I have known a gentleman a little over fifty, apparently in perfect health, break his thigh with a loud snap whilst turning in bed. In cases of spontaneous fracture union rarely takes place, or not without much difficulty.

VARIETIES.—Fractures present important varieties as to their *Nature* and their *Direction*.

Nature.—Fractures are divided first into three classes, *Simple*, *Compound* and *Complicated*. A fracture is said to be **Simple** when it is not accompanied by an open wound communicating directly with the seat of fracture.

When the soft parts are torn through, so that the fracture communicates by a wound with the surface of the body, it is said to be **Compound.** A fracture may be rendered compound in three ways: 1. Through laceration of the soft parts by the same injury that breaks the bone, as by a bullet in traversing a limb. 2. By the protrusion of one of the fragments through the integuments. This necessarily most frequently happens when the fragments are sharp and pointed, and the coverings thin, as in fracture of the tibia, and may be occasioned by muscular contraction, by some incautious movement on the part of the patient, or by roughness on the part of those lifting or carrying him. 3. By the sloughing of bruised tissues or by the gradual ulceration of a projecting fragment through the skin.

It is important to distinguish between fractures that are primarily compound, that is, that are compound from the first, and those in which a wound leading to the broken bone forms some time after the accident, as the result of inflammation, suppuration, and sloughing, or from other causes. When the fracture becomes compound secondarily, the danger is greatly lessened, on account of the reparative tissue that has formed at the seat of the injury having closed the medullary canal in such a way that septic osteomyelitis is not likely to occur. The blood-clot and the early exudation are also to a great

extent absorbed and the intermuscular spaces around sealed by coagulated inflammatory exudation or granulation-tissue, and thus deep burrowing of septic matter in the limb is not likely to take place, and the danger of septic absorption or pyæmia is greatly diminished.

A fracture is said to be **Complicated** when the injury to the bone is conjoined with some other condition which is perhaps of more importance than the mere fracture, and often greatly influences the result of the case. Thus, a fracture may be complicated with injury of an important internal organ—as of the brain, lung, or bladder—usually inflicted by one of the fragments. A fracture may also be complicated with the wound of one of the principal arteries, especially in the leg, where the tibial vessels lie in close contact with the bone, and are sometimes torn by the broken ends. In other cases again, the fracture is associated with injury of a joint or with dislocation.

Fractures are also divided into the **Single Fracture**, where the bone is merely broken across, split, or fissured; the **Comminuted** (Fig. 158), where the bone is broken into several fragments at one place; the **Impacted**, where one fragment is wedged into another, the compact tissue being driven into the cancellous; and the **Multiple**, where there are more fractures than one, either in different bones or in different parts of the same bone.

Fig. 158. — Comminuted Fracture made by gun-shot.

Besides these varieties of fracture, it occasionally happens that a bone is only cracked, or partially broken. This especially occurs in the bending of bones in children, in which cases the fracture may be **Partial** or **Incomplete**, merely extending across the convexity of the curve made by the bone. This is commonly called the "*green-stick*" fracture.

Direction.—The direction assumed by fractures varies greatly, and depends materially on the cause of the injury, as well as upon the bone that is fractured. The line of fracture may run through a bone in three different directions: either *transversely*, *obliquely*, or *longitudinally* to its axis.

The **Transverse Fracture**, when met with in the shaft of a long bone, is usually the result of direct violence, and may therefore be accompanied by considerable injury to the soft parts. In this situation it is always more or less toothed and irregular. It is more commonly met with at the articular ends of the long bones, as at the lower end of the radius, the upper end of the humerus or the neck of the femur, and it is then almost invariably caused by indirect violence. In children it often occurs between the epiphyses and the shaft of a long bone. In the patella transverse fracture is the common form met with as a result of violent muscular action, while in the vertebræ and sternum it is usually produced by indirect violence. In the long bones a transverse fracture unites readily and with but little displacement.

The **Oblique Fracture** commonly occurs from indirect violence; the breaking force being applied to the ends, and not across the shaft. It often runs a long way, sometimes nearly half the length of the shaft of a bone, and is more dangerous than the transverse, owing to the obliquity of the fracture causing the ends of the bone to be sharply pointed (Fig. 159), and thus

described (p. 361). When produced by a puncture or a clean cut, antiseptic treatment and immobility will usually ensure a cure without the functions of the joint being in any way impaired. Thomas's knee-splint will be found the most convenient form of apparatus for fixing the joint. Should suppuration occur, the joint must be laid open unsparingly. The finger should be inserted at the original wound, if it be situated towards the front of the joint, and pushed down to the most dependent part of the synovial pouch; here the tip of the finger may be made to project and be cut down upon. A probe-pointed bistoury is then to be introduced and the incision extended till it reaches from the head of the tibia to the upper limit of the synovial pouch. The knife should be slanted backwards so as to facilitate drainage. The opposite side of the joint must then be treated in the same way. Even after this amputation may be necessary, and the incisions above described can be used in the operation. If the drainage is inefficient, abscesses will often form deeply, the pus bursting from the joint by the upper part of the synovial pouch, and burrowing up the thigh under the vasti, reaching sometimes as high as the trochanter before it is detected. At the time the synovial pouch gives way the relief of tension may cause a deceptive abatement in the severity of the symptoms; but soon the limb swells up to the trochanters, becomes tense, painful, hot, and œdematous, with great constitutional disturbance and high fever, though the joint may be but little swollen, and many days will often elapse before fluctuation can be again felt in it or in the thigh. This absence of swelling in the knee itself may mislead an inexperienced practitioner. At length the abscess may approach the surface near the knee; and, on an incision being made, an immense quantity of pus is discharged. It is the depth in the limb at which the abscess is seated that gives rise to the difficulty in its detection, the violent constitutional disturbance it occasions, and its extreme danger. I have never seen abscess form amongst the muscles of the leg as a consequence of injury of the knee-joint, unless the tibia had been fractured as well as the joint opened.

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Wounds of the **Wrist-joint** are peculiarly dangerous, on account of the extent and complexity of the synovial membrane that enters into its conformation. Should suppuration be set up, some of the carpal bones may necrose. In these circumstances, if the patient be in good health and not too old, excision of the joint will leave a very useful hand; when excision is not practicable, amputation must be performed, if possible, by a flap taken from the palm, only the diseased articular ends of the radius and ulna being removed. In some cases the patient may recover without operation, but a stiff and comparatively useless hand will generally be left.

DISLOCATIONS will be described in Chapter XXII.

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The worst forms of fracture are occasioned by **direct external violence** crushing and splintering the bone, as by the passage of a heavy wheel or by a gun-shot injury. The fracture always occurs at the point to which the force is applied and is often complicated with considerable mischief to the soft parts.

Indirect violence may break a bone in two ways. One that is more commonly talked of than seen is by *contrecoup*, in which, when a blow is inflicted on one part, the shock that is communicated expends its violence on the opposite point, where the fracture consequently occurs. This form of injury has been described only in the bones of the head. (See Chap. XXIV.)

In the other form the bone is broken by being snapped, as it were, between a resisting medium at one end, and the weight of the body on the other. Thus, a person jumping from a height and alighting on his feet may break his legs by their being compressed between the weight of the body above and the ground below. The long bones are those which are most frequently fractured in this way; and the fracture occurs at the greatest convexity, or at their weakest point. When a person jumps from a carriage that is in motion, although the height of the fall be not great, yet its force is considerable, the feet coming violently to the ground and being suddenly fixed, while the body moves with the same velocity as that with which it was being carried onwards in the vehicle. Hence, fractures received in this way are usually severe, and often compound or comminuted.

Muscular action is not an unfrequent cause of fracture of bones into which powerful muscles are inserted; especially the patella, the olecranon process of the ulna and some of the bony prominences, such as the acromion, which are broken in the same way that a tendon is ruptured—by the violent contraction of the muscles attached to them tearing them asunder. It is not often that the long bones are so fractured; but the humerus has been broken by a person striking at but not hitting another, or by suddenly throwing out

the arm to seize something that was falling; and the clavicle has been fractured by a rider giving his horse a back-handed blow. In these cases, however, muscular action may not have been the sole cause, the weight of the limb also tending to fracture the bone. Muscular action also aids in the fracture of bones by indirect violence; thus we see that a sober man who makes a violent effort to save himself more often breaks a bone in a fall than a drunken man who falls like a log.

Predisposing Causes.—Some bones are especially liable to be broken in consequence of their *serving as points of support*. Thus, when a person falls upon the hand, the shock is transmitted from the wrist through the radius, humerus and clavicle, to the trunk; the radius and clavicle, being the weaker bones, are then especially liable to be fractured. So again, the *situation* of a bone, irrespectively of any other circumstance, may predispose it to fracture; the prominent position of the nasal bones, and the exposed situation of the acromion, render these parts peculiarly liable to injury. The *shape* of some bones disposes them to fracture; thus, a long bone is necessarily more readily broken than a short and thick one; hence the tibia and femur are more often fractured from falls on the feet than the os calcis. *Certain parts of bone* are more commonly fractured than others. Those parts especially into which powerful muscles are inserted, or that are in exposed situations and hence liable to injury, or have to receive the weight of the falling body, are often broken. Hence the clavicle, the olecranon, and the neck of the femur, are commonly fractured.

Age exercises considerable influence, not only on the general occurrence of fractures, but on the liability of certain bones to be broken. Fractures may occur even in intra-uterine life, and many cases have been recorded in which one or more bones have been broken in the fœtus by blows upon the abdomen of the mother during the later months of pregnancy. Intra-uterine fractures may also occur as a consequence of syphilis; thus Chaussier dissected a syphilitic fœtus that had 113 fractures and another with 43. Fractures may occur also during birth, most commonly of the humerus or femur but occasionally of the bones of the skull. These are usually the consequence of instrumental delivery. Some cases that have been described as congenital fractures appear to me rather to be instances of arrest of development or failure of union between the various parts of the bone. These show no disposition to union or the formation of callus and I have never seen any operation such as wiring, scraping, &c. undertaken for their cure with success.

In early age, as the bones are elastic and partly cartilaginous, fractures occur less readily than in advanced life when they have become brittle and earthy. In children fractures frequently occur at the line of junction of the shaft with the epiphysis where ossification has not as yet become perfect. This separation of the epiphysis occurs chiefly at the lower ends of the humerus and femur, sometimes in the radius and other long bones. As age advances, the compact tissue of the shaft becomes denser and harder, but the cancellous structure of the extremities more dilated and looser; hence fracture of the neck of the femur is especially common in old people. In young persons the bone is usually broken transversely, but fractures taking place at a more advanced period of life are generally oblique, and often comminuted; in adults they also more commonly extend into joints than when occurring in early age. In children, more than one half the fractures

occurring in the upper limb are of the clavicle; and in the lower limb, fracture of the shaft of the femur by indirect violence is of extremely common occurrence.

Sex indirectly influences the liability to fracture, men being more frequently exposed to the causes of this injury than women. In women, the bones that are most commonly fractured are the clavicle, the radius, the tibia, and the neck of the femur; in men, the shafts of the long bones, the cranium, and the pelvis.

From statistical tables of fractures of the upper limb given by Flower, it appears that below five years of age the liability of the two sexes to fracture is equal. After five, the males steadily increase in liability up to middle life. After forty-five, the number of fractures of the upper limb in females exceeds that in males, in consequence of the extreme frequency of fracture of the lower end of the radius in women above middle life.

Side of the Body.—From the statistics of Gurlt, Middeldorpf, Lente and others, it would appear that fractures occur with about equal frequency on the two sides of the body.

Time of Year.—The popular supposition that the bones are more brittle in winter, and hence break more readily than at other seasons, is altogether a mistake; though fractures may be common at this period of the year, from falls being more frequent during frosty weather.

Spontaneous Fractures are those which happen without any very distinct cause, or under the influence of violence that would usually be insufficient to produce such an injury. They arise from various pathological conditions, amongst which the following are the chief. *Atrophy of Bone* occurs naturally in old age, and is, as before stated, a powerful predisposing cause of fracture; but mere senile atrophy seldom reaches such a degree as to lead to spontaneous fracture. In the same way atrophy from want of use may render the bone brittle, so that a very small force may break it, as we occasionally see in attempted reduction of old dislocations. A much more important form of atrophy is that which accompanies certain forms of disease of the central nervous system, especially general paralysis of the insane. Bruns has collected the records of sixty cases of spontaneous fracture occurring in the insane, and amongst these were many instances of multiple fractures. In some of these cases the bones were found to be greatly atrophied, and in one they were easily cut with a knife. General paralysis is not unfrequently complicated by violent maniacal attacks, and in the necessary restraint at these times it has happened that one or more of the patient's bones have been broken although no undue force has been employed. These cases have more than once given rise to charges of cruelty or manslaughter against the keepers in lunatic asylums. Spontaneous fractures occurring in *locomotor ataxy* have been described by Charcot, Weir Mitchell and others. These, like the joint affections of this disease, appear usually to occur in the early stage, before the development of ataxic symptoms. *Mollities ossium* is, as will be seen when that disease is described, often associated with spontaneous fracture. *Rickets* is more often a cause of bending or partial fracture under considerable violence, but cannot be said to be a cause of true spontaneous fracture. *Scurvy* was said by the older writers to cause a general weakness of the bones, but later observations have not confirmed this. In children it is said to predispose to separation of the epiphyses. *Constitutional Syphilis* was formerly believed in some cases to cause a general

thus the chief displacement in a broken leg is caused by the muscles of the calf. When one set of muscles is attached to the upper fragment and their opponents to the lower, as in the case of fracture of the radius above the insertion of the pronator radii, then the broken ends may be widely separated. As a rule, more than one cause is concerned in producing the displacement, but in some cases, as in fractured patella and fractured olecranon, muscular contraction acts alone.

The amount and direction of the displacement is often determined by the nature of the fracture. In longitudinal fractures there is no displacement; in transverse fractures the fragments may lock into each other and the displacement may be very slight. In oblique fractures the fragments commonly "ride" one over the other.

The **Direction of the Displacement** is influenced by the direction of the fracture, the position of the limb and muscular action; it may be angular, transverse, longitudinal, or rotatory. In the *angular* displacement there is an abnormal curvature of the limb, and one or both ends of the broken bone may form a marked projection on the convex side of the curve. The concavity is usually on the side of the most powerful muscles. Thus in fracture of the middle of the femur, the angle projects on the anterior and outer side of the limb, the upper fragment being flexed, abducted, and rotated outwards by the psoas and iliacus and the external rotators, and the angle thus formed increased by the powerful flexors passing from the pelvis to the bones of the leg. Angular deformity is most common in oblique fractures.

The *transverse* or *lateral* displacement occurs when a bone is broken directly across. The fragments often hitch one against another, thus being, as it were, entangled together, and in this case there is often but very little deformity.

Longitudinal displacement is invariably shortening when the fracture occurs in the shaft of a long bone. It is due in most cases to muscular action, the broken ends of bone being brought together so as to overlap or "ride" over one another. In other cases, the shortening may be owing to the impaction of one fragment into the other. In some cases there is preternatural separation of the fragments, the weight of the limb tending to drag the lower one downwards, as in some rare fractures of the scapula, or muscular contraction drawing the upper one away from it, as in fracture of the patella.

The *rotatory* displacement may be owing to the contraction of particular sets of muscles, twisting the lower fragment on its axis as well as producing shortening of the limb. Thus the pronators in some fractures of the radius have a tendency to rotate the lower fragments inwards. In other cases the line of obliquity of the fracture may determine the rotatory displacement; and in the lower extremity the weight of the limb will always turn the lower fragment outwards, just as the leg of a dead body rolls on to its outer side.

2. **Preternatural Mobility in the Continuity** of a bone cannot exist without fracture; hence, its presence may always be looked upon as an unequivocal sign of broken bone. But fracture may exist without it when the fragments are impacted firmly one into the other.

3. Another sign of much value is the **Crepitus** or **Grating together of the Rough Surfaces of the Broken Bone**, which can be felt as well as heard on moving the limb. This can be elicited only when the fragments are movable and in contact. It is not, however, an invariable accompaniment of fracture; being absent when the fracture is firmly impacted or the fragments

are widely separated. It must not be confounded with the crepitation that occurs from other causes, as from emphysema. The effusion of serous fluid into the sheaths of the tendons gives rise to a peculiar crackling sensation, easily distinguished from the rough grating of a fracture. There is a species of false crepitus also experienced sometimes in injuries of joints, consisting of a snap or click rather than of true grating, which is sometimes mistaken by inexperienced practitioners for true crepitus of broken bone. The roughened surfaces of a joint in the later stages of chronic rheumatic arthritis, will, however, give rise to a grating which it is very difficult to distinguish from that of a broken bone. As a rule it is finer and more regular than the crepitus of a fracture.

In some cases in which the mobility cannot be clearly felt, the patient will complain of pain at the seat of fracture when an attempt is made to find it, or when a distant part of the bone is pressed on. This is often a very useful means of diagnosis in fractures of the fibula and ribs.

It will thus be seen that no one of these three signs alone is absolutely to be relied upon, and a combination of at least two of them is usually required to determine whether fracture exists. In ascertaining the existence of a fracture, the Surgeon should make the necessary manipulations with the utmost gentleness, but yet effectually, so that no uncertainty may be allowed to remain as to the seat and nature of the injury, more especially when it occurs in the vicinity of a joint. The increased mobility may be ascertained by fixing the upper fragment and rotating the lower portion of the limb; the crepitus by drawing down the lower fragment, so as to bring the rough surfaces into apposition, and then grasping the limb at the seat of fracture with one hand, and rotating it gently with the other. The displacement must be ascertained by measuring the limb carefully in the way that has been directed, and by comparing the injured with the sound side.

DIAGNOSIS.—The diagnosis of a *simple* fracture is usually made without difficulty by the co-existence of displacement, abnormal mobility, and crepitus. There are, however, two conditions that may render the detection of a simple fracture difficult. The first is, when only one of two or several contiguous bones is broken; the other, when the fragments are impacted.

When only one bone is broken in a situation where there are two or more, as in the leg, forearm, metacarpus or metatarsus, very close and careful manipulation of the injured bone may be required. The Surgeon must run his finger carefully over the most projecting ridge, feeling for slight inequality or swelling at one part, or perhaps he may elicit faint crepitus on freely and deeply moving the bone at the seat of suspected fracture; or, failing this, severe pain may be caused in the line of the bone by forcing its two extremities towards each other, or by applying force in such a way as to bend it.

In the case of *impaction* the diagnosis is even more difficult. Here no crepitus, and no preternatural mobility, can be found, and the Surgeon must be led to his diagnosis by the recognition of the characteristic displacement of the particular fracture, as, for instance, the deformity of the wrist in impacted fracture of the lower end of the radius.

The difficulties of diagnosis are necessarily most seriously increased if there be much extravasation of blood; or, when the fracture is through an articular end, if there should be much effusion into the neighbouring joint. In cases of doubt it is wiser to put up the limb as if there were a fracture, and to wait

e subsidence of the swelling before the diagnosis is finally made. It better to put up an unbroken limb than to neglect to put it up if red.

e existence of a fracture when *compound*, and more particularly if *inuted*, is usually readily determined. Here, the great mobility, the rusion of fragments or splinters, and the easily produced crepitus will om allow the Surgeon to be in error. Should any doubt exist, the intro- tion of the finger into the wound will enable him to determine with tainty, not only the existence, but the condition and extent, of the fracture; t on no account must a probe or metal instrument of any kind be used, or a nple fracture complicated with a wound may accidentally be made com- und; *nor should the finger ever be introduced without rst thoroughly purifying the hand with some efficient ntiseptic solution.* Nevertheless, with all the assist- nce that may thus be afforded, the existence of a compound and comminuted fracture may be unsus- pected for many days even after the most careful examination. Of this important fact, which may have weighty medico-legal bearings, the following case is a good illustration. A young man was shot with a wooden ramrod through the left hand and shoulder, by the accidental explosion of his gun whilst he was loading it. The ramrod struck the humerus three inches below the shoulder-joint, on its fore part. It was splintered against the bone, the frag- ments passing on each side, and mostly escaping through two apertures pos- teriorly; some passing to the inner side between the large vessels and the bone, the others to the outer side between it and the deltoid. The patient was brought to the Hospital, where I saw him a few hours after the injury, and, enlarging the wounds, extracted a number of splinters of the ramrod from around the bone. The limb carefully examined, not only by me, but by several other Surgeons present determine whether the bone had been fractured, or the joint injured, bu sign of fracture was detected. The limb was laid on a pillow, and irrig employed. Septic cellulitis set in, followed by extensive and deep suppur in the limb. On examining this, with the view of giving a free exit t discharges, eight days after the accident, angular displacement and cr were for the first time found, and it became evident that the humeru the seat of a comminuted fracture. The patient died of pyæmia; an death the bone presented the appearance shown in Fig. 160, a long s having been detached in a longitudinal direction, A B, and the shaft across at C. It appeared probable that the blow of the ramrod had fr the bone longitudinally, detaching the large splinter, which had

Fig. 160.—Comminuted Fracture of the Humerus without displacement.


Fig. 161.—Fractured tibia fr a dog on the tenth d Showing the external internal provisional calli

enclose spaces containing the vessels and cellular elements, and so-called osteoid tissue is formed. In that part of the callus, on the other hand, which lies opposite the line of the fracture, true cartilage is formed; whilst in that portion which is intermediate between these two extremes a transitional tissue is produced, the cells of which resemble those of cartilage, but the matrix of which differs from that of cartilage in that it stains deeply with carmine. The formation of true cartilage invariably occurs in animals, but only under certain circumstances in the repair of fractures in man. This fact and the relation of the cartilage, when present, to the line of the fracture, suggest that its formation is in some way determined by want of rest.

Changes similar to those above described occur in the medullary canal, true cartilage being formed only at the immediate seat of fracture.

The complete ossification of the provisional callus.—The formation of new bone in the soft callus commences by the appearance of yellowish-white points or streaks, first seen in the part in contact with the bone at the point furthest removed from the seat of fracture. These points and streaks gradually increase till the callus becomes converted into soft spongy bone, containing wide cancellous spaces filled with red vascular medullary tissue. The ossification gradually spreads from above and below, towards the seat of fracture, till the process of conversion of the soft callus into bone is complete. The changes that occur within the medullary canal are of the same character. The new bone thus formed differs from normal compact tissue in being softer, more vascular and spongy. If a longitudinal section of the bone be made, it will be seen that the callus is covered by a thick vascular periosteum which can be stripped off without difficulty; it leaves the surface of the callus rough and spongy, with wide Haversian canals containing some red medullary tissue. The trabeculæ of the callus are set at right angles, or nearly so, to the surface of the compact bone beneath, from which the callus can at first be separated without difficulty. If this be done, however, the surface of the compact bone is seen to be slightly more spongy than natural, the openings of the Haversian canals being enlarged.

Microscopic examination shews that when ossification occurs in that part of the callus which has undergone conversion into osteoid tissue, the process consists in the deposit of bone by osteoblasts, layer by layer, on the surfaces of the trabeculæ of lime salts which have already been formed in the ground-substance. The spaces around the vessels are thus gradually narrowed until they assume the form of Haversian canals, whilst many of the osteoblasts become imbedded in the osseous tissue as bone-corpuscles. In that part of the callus in which true cartilage is developed, the process of ossification is preceded by the penetration of vessels into the cartilage from the periosteum and from the bone beneath, whilst the further changes observed are similar to those met with in the normal process of ossification in cartilage.

The ossification of the callus in the medullary canal proceeds in the same way.

The *development and ossification of the intermediate* or *definitive callus* proceed in the same way as in the formation of the provisional callus. The time at which it forms will depend greatly upon the perfection of the apposition, and the immobility attained by treatment. It is evident that no process of repair can take place between two surfaces of compact bone so long as they are grinding against each other at each movement of the limb. The

point of fracture, are more or less extensively lacerated; the periosteum a rule completely torn through, and separated from the broken ends for a distance on one or both sides, leaving a ragged edge. In some cases the osteum on one side may be intact, and it is said to have been found un- even in complete fractures. As a rule it remains uninjured over a simple ure. Blood will be found extravasated also in the medullary canal mixed with the fat.

The *Period of Inflammation and Exudation*.—The first changes observed ter the injury are the ordinary signs of inflammation—hyperæmia, swelling, nd abundant exudation. This affects the whole of the injured soft parts, so hat by the third or fourth day the fracture will be found to be surrounded by a greyish-red, soft mass, not sharply defined, but infiltrating the neighbouring tissues; the torn ends of the muscles are pale in colour from the exudation between the fibres; the areolar tissue is no longer clearly recognizable, its spaces being filled by the coagulated inflammatory exudation; the outer layer of the periosteum is in like manner swollen and scarcely recognizable, and the inner layer is so soft and swollen as to be almost gelatinous; the whole membrane can be stripped from the bone with unnatural ease for some distance from the seat of fracture. In the midst of the exudation, patches of unaltered blood-clot will still be seen, but a great part of the extravasation in the immediate neighbourhood of the fracture will have already been partly discoloured.

Microscopic examination at this stage shows the usual appearances of inflammation; the vessels are distended with blood, and all the spaces of the tissues are filled with wandering white corpuscles, either closely in contact with each other, or separated by a small quantity of homogeneous or fibrinous intercellular substance.

In the medulla the fat has disappeared from the immediate neighbourhood of the injury, and its place is taken by an exudation similar to that lying externally.

The growth of the soft provisional callus.—During this stage the excess of the inflammatory exudation and the remainder of the blood-clot in the neighbourhood of the injury are absorbed, and there is gradually developed round the ends of the broken bone a fusiform mass, holding them together with some degree of firmness. At first this is soft, almost jelly-like, and homogeneous in appearance, and the ends of the torn periosteum become lost in it. This soft provisional callus presents under the microscope the ordinary appearances of granulation tissue, but close to the bone many cells are found of larger size than the rest, and having one or more nuclei surrounded by a finely granular protoplasm. These *osteoblasts* are usually oval or spindle-shaped, or sometimes angular in form. They play, as we shall see, a most important part in the process of repair, and probably take their origin in the deeper layers of the swollen periosteum.

The callus next increases in density, and the superficial part undergoes the ordinary changes of the conversion of granulation tissue into fibrous tissue, thus forming the fibrous part of the new periosteum covering the callus. The changes which occur in the deeper parts of the provisional callus differ according to its situation. They are thus described by Bruns. In the part m stant from the line of the fracture, lime salts are deposited in the form trabeculæ in the intercellular ground-substance. These trabeculæ

found exactly opposite the seat of fracture, where there will necessarily be the greatest disturbance from movement.

Modification of Union of Simple Fracture.—The amount of callus formed in the union of a bone varies considerably. It is greater in children than in adults. In transverse fractures which are kept steadily in apposition, but little callus is formed; externally it may be scarcely perceptible, and internally it may be merely a thin tube not obliterating the medullary canal. It is greater in those bones and those parts of a bone which are thickly covered by soft parts, being formed as before stated not only from the periosteum and bone, but also from the surrounding tissues. The influence of the neighbouring soft parts in determining the formation of new bone is well marked in the tibia. In a fracture of this bone we find that, at the anterior and inner part, which is thinly covered, union takes place by the direct formation of intermediate callus; but at the posterior and outer side, where there is a thick envelopment of tissue, a large mass of provisional callus will often be found, filling up even the interosseous space. Occasionally we find that the inflammation set up around a fracture has extended to a neighbouring bone, and caused a formation of new bone upon it.

The formation of callus is also greatly influenced by the nature of the fracture. If the fracture be comminuted and the fragments displaced, there may be an abundant formation round the splintered fragments, welding them together. If there be great displacement, one end riding far over the other, the callus will be found chiefly between the two fragments, connecting them together by a bridge of bone. So also, in cases of great angular deformity, when the final process of partial absorption and moulding of the new bone has taken place, a larger amount is left in the angle, partly filling it up, and forming a sort of buttress to strengthen the bent bone. Lastly, the amount of callus is influenced very greatly by treatment; the more perfectly rest is maintained, the smaller will be the amount of callus formed.

Union of a separated Epiphysis takes place in the same way as union of a transverse fracture. It almost invariably causes complete ossification of the epiphysial cartilage and consequent arrest of growth from that end of the bone.

Clinical Course of a Simple Fracture.—The great majority of simple fractures of the larger bones are followed by slight febrile disturbance. This is very rarely sufficient to give rise to the general symptoms of fever, such as heat of skin, thirst, headache, &c.; in fact without the thermometer its existence could seldom be recognized. The temperature rarely exceeds 101° F., and in fact seldom reaches this point, unless there be considerable tension of the limb from extravasated blood. The nature and causes of the fever which accompanies simple fractures have already been discussed (see p. 306). The temperature usually becomes normal about the end of the first week, and from that time to the end of the case the patient suffers from no disturbance of health save such as may be caused by want of exercise if the fracture be situated in the lower limb.

TREATMENT OF FRACTURE.

In the treatment of an uncomplicated simple fracture, all that the Surgeon has to do is to place the fragments in proper position and to retain them there,

first change observed is an enlargement of the Haversian canals. This is effected by the growth of new cells within the canal. These, according to some pathologists, are migratory white corpuscles, but according to others, cells developed from the medullary tissue in the Haversian canals. Be this as it may, the bony wall of the canal is absorbed before the new cells. As soon as the opposing fragments are put at perfect rest the new cells sprout out from the canals on each side and fill the space. Ossification then proceeds in the new tissue thus formed, but without the previous formation of cartilage.

The *absorption of the provisional callus* forms the final stage of repair of a fracture. At first the porous callus becomes more compact, harder, and less vascular, and as the change takes place, it becomes more intimately connected with the old bone which it now closely resembles in structure. This hardening is most marked in the deeper layers in contact with the old bone, and as it takes place absorption goes on in the part next the periosteum, which at the same time becomes smooth and even. In the medullary canal the new bone becomes more and more cancellous in its structure, and finally there may be complete restoration of the medullary canal, though this is undoubtedly rare. The absorption of the callus is never complete, some thickening permanently remaining at the seat of fracture, however perfect the apposition and rest may have been. Any irregular points of bone, that may have been projecting after the union, become gradually absorbed and rounded off. These final processes are not completed for a year or more after the fracture has been united.

The microscope shews that the agents by which the absorption of the provisional callus is brought about are large multinucleated cells, known as *osteoclasts*, which apply themselves to the surface of the bone, and produce pits or hollows upon it known as "Howship's lacunæ."

Thus, it will be seen that the process is analogous in every way to repair of a wound by the first intention. First there is the exudation resulting from the simple traumatic inflammation, the effect of the mechanical violence; then follows the development of a vascular tissue, composed of indifferent embryonic cells or granulation-tissue; this develops into the form of connective tissue natural to the part; and finally the obliteration of vessels and consolidation of the cicatricial tissue occur, as in the formation of a scar in the soft parts. One point with regard to the blood-clot should be remembered, as it might be of importance in medico-legal enquiries. Although it completely disappears from the immediate neighbourhood of the fracture at an early period, layers of dark coagulum may often be found beneath the superficial fascia for four weeks or more after the accident.

The process above described, although essentially the same in man, differs much in its details. It is slower, and the formation of callus is as a rule less abundant. If the fracture be well treated, it may in fact be almost wanting, union apparently taking place by the direct, or almost direct, formation of the definitive or intermediate callus. Histologically, the most important difference is that in man, as a rule, the formation of cartilage does not occur. It has, however, been met with in the union of bones in children, and it is always found in a uniting rib, but even here it is seldom pure, the ground-substance being usually fibrous. Possibly the formation of cartilage in the rib may be due to the impossibility of fixing the injured bone, owing to the movements of respiration. In animals, the purest cartilage is

found exactly opposite the seat of fracture, where there will necessarily be the greatest disturbance from movement.

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TREATMENT OF FRACTURE.

In the treatment of an uncomplicated simple fracture, all that the Surgeon has to do is to place the fragments in proper position and to retain them there,

and to attend to the general health of the patient on ordinary principles. Nature unites the bone. In no way can the Surgeon accelerate the process or improve upon it, but by meddlesome treatment he may retard and disturb it.

Constitutional Treatment in Simple Fractures requires but a very few words of explanation. As a rule, the general habits of life should be interfered with as little as possible. In uncomplicated fractures of the upper extremities, more especially in the young, rest in bed is rarely necessary. The patient may be allowed to move about with the limb supported by proper apparatus. In fractures of the lower extremities, with few exceptions, confinement to bed, during part of the treatment at least, is unavoidable. In these cases the diet may be reduced, and aperients will usually be required during the first week or ten days. After this the usual habits of life may be resumed.

In old persons the shock of the accident, the enforced confinement to bed and the sudden interruption of the ordinary habits of life, are apt to exercise an injurious and sometimes a fatal effect. In these cases there are two dangers to be feared, viz., hypostatic congestion of the lungs and the formation of bed-sores. Both are avoided by propping the patient up in bed, the use of water or air cushions, and change of posture as far as practicable. It is necessary to see that the bed is smooth and firm, without creases; that all crumbs be swept away daily; and that scrupulous attention be paid to cleanliness after the use of the bed-pan. Good diet and a fair allowance of stimulants are needed in these cases. The early use of the starched or plaster-of-Paris bandage is of great service in enabling the patient to get up sooner than would otherwise be possible.

In all cases of simple fracture of the lower extremities, the sooner the patient is got up and about on crutches the better. Some patients speedily learn to use these instruments, others never get accustomed to their use. In the latter case, a wheel-chair should be substituted for them.

Surgical Treatment of Simple Fracture.—The object of the Surgeon is not only to obtain a sound and strong limb, but one that presents little or no deformity. In order to accomplish this, the broken ends of the bone must be brought into as perfect apposition as possible, and the recurrence of displacement must be prevented.

It frequently happens that a Surgeon is called to a case of fracture immediately after the accident before the patient has been moved, and without being informed of the nature of the case. It is then his duty to see that the moving of the patient is done as far as possible painlessly and without increasing the injury to the soft parts by needless movement of the limb. For this purpose temporary splints may be applied outside the patient's clothes, and secured, in the absence of bandages, by pocket-handkerchiefs tied round the limb. A couple of walking-sticks or umbrellas, or the handle of a broom, may thus be applied to the thigh or leg; or a splint cut from the cover of a book to the arm. Newspapers folded several times till they form a mass of sufficient stiffness make excellent temporary splints.

If the patient has already been moved and is upon a bed, the limb must be placed in such a position as to give the greatest general relaxation of the muscles. Thus the lower limb must be flexed and placed on its outer side with a thin pillow under the knee. In fractures of the upper limb the arm should lie on a pillow by the side with the elbow flexed. The patient is thus made as comfortable as possible, while the necessary preparations are being

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Reduction.—When all is ready, the reduction of the fracture, or the bringing the fragments into proper apposition, must be proceeded with. This should be done *at once*, not only lest any displacement that exists may continue permanently—the muscles, after a few days, becoming shortened, rigid, and unyielding, not allowing reduction to be effected without the employment of great force—but also with the view of preventing irritation and mischief to the limb, by the projection of the jagged ends of bone into the soft structures. A great deal of time is sometimes lost, and much un-necessary pain inflicted upon the patient, and great irritation set up in the limb, by the Surgeon leaving the fracture unreduced on a pillow for several lays, and applying evaporating lotions to take down the swelling and avert he threatened inflammation, which are consequences of the non-reduction of he broken bone. The application of cold lotions, irrigation, &c., in com-ound or even in simple fractures, is decidedly injurious. It lowers the itality of the part, retards union, and occasions œdema. By early reduction e may sometimes prevent a sharp fragment from perforating the skin, and us rendering a simple fracture compound, or lacerating muscles and nerves, ducing perhaps traumatic delirium and certainly undue local inflammation d muscular spasm.

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must then be put in the best position possible, and firmly supported by splints rather tightly applied. When everything is ready the injured limb must be confided to the charge of one assistant only. If two attempt to hold a leg, one by the foot and the other by the knee, they may cause the very mischief it is intended to prevent.

Conway, of New York, has succeeded in preventing the severe pain of reduction by means of cocaine. In a case of fractured radius he injected hypodermically miii. of a 4 per cent. sterilized solution of cocaine between the broken ends, and a few minutes later mxiv., part deeply and part superficially. Immediately after the last injection he applied a tourniquet above the elbow. In five minutes the limb could be manipulated without pain. The anæsthesia lasted for half an hour while the tourniquet was on, but disappeared in fifteen minutes after its removal.

Prevention of Return of Displacement.—After reduction has been accomplished, means must be taken to prevent the return of the displacement. We have already seen that the three great causes of displacement in a fracture are, external violence, the weight of the limb, and the contraction of the muscles. In the upper limb the weight is supported during the treatment of the fracture when necessary by slings or bandages. In the lower limb the chief displacement due to the weight of the limb is rotation outwards; this is prevented by lateral splints. The displacements due to muscular action are far the most troublesome, and in many cases it is exceedingly difficult, for the first few days, to keep the ends of the bone in position, in consequence of spasmodic contractions of the muscles, or of restlessness of the patient. About this, however, the Surgeon need not be anxious, as no union takes place for the first week or ten days; at the end of that time the muscles will have lost their irritability, and the patient have become accustomed to his circumstances, so that with patience, and by varying the apparatus and the position of the limb from time to time, good apposition may be obtained.

The displacements due to muscular action are overcome chiefly in two ways which may be used together or separately—**relaxation and extension.** The principle of **relaxation**, first laid down by Pott, consists merely in placing the limb in such a position as to relax the chief disturbing muscles. There is no doubt it is of the greatest value in the treatment of the majority of broken bones. **Extension** consists in applying an apparatus by which the lower fragment is pulled in the direction opposite to that in which the muscles are displacing it. In order to apply it efficiently, counter-extension must be made upon some part of the body above the fracture. Extension is usually made by the Surgeon pulling forcibly on the lower fragment, the apparatus being used merely to retain the limb in the position in which he has placed it; in some cases, however, elastic extension is applied during the subsequent treatment by means of india-rubber. Considering the power of the muscles, it is evident that in many parts it would be impossible to apply sufficient force to overcome the displacement to which they give rise. It seems, however, that long-continued and steady extension gradually tires out the muscles until they yield to it. Extension should therefore be constant. It is most useful in longitudinal displacement, but it also aids the reduction of angular deformity. As types of the application of these two principles, the treatment of fracture of the thigh by the double inclined plane, and by the long splint, may be referred to.

A third method of overcoming muscular action has been suggested: **the division of the tendons** of some of the stronger muscles inserted into the lower fragment. This, however, can very seldom be necessary, and I have rarely seen any benefit result from it. Displacement due to the violence which caused the fracture is overcome at the time of reduction; any further displacement from external causes is prevented by the treatment about to be described.

The return of displacement is prevented, and the proper shape of the limb maintained, by means of *bandages*, *splints*, and *special apparatus* of various kinds. In applying these care should be taken not to exert any undue pressure on the limb. Pads and compresses of all kinds intended to force a displaced fragment into position should, if possible, be avoided; they do nothing that cannot be effected by proper position, and may occasion sloughing of the integuments over which they are applied.

The **Bandages** used in the application of splints should be the ordinary grey calico rollers, about two or three inches in width, and eight yards in length. Special care must be taken that the turns press evenly upon every part, and that the bandage be not applied too tightly. *No bandage should be applied under the splints*, more particularly at the flexures of joints, and care must be taken that the limb be not bent, or its position otherwise materially altered, *after* bandages have been applied. A bandage *under* the splint is not only useless, but dangerous, from the risk of strangulation. No bandage should be applied to the seat of fracture. The part below may sometimes advantageously be bandaged, in order to prevent œdema; thus, in fracture of the humerus, the forearm may be bandaged, but no turns of the roller should be brought above the elbow. This point of practice I consider most important, as the application of a bandage to the immediate seat of fracture causes not only great pain, but danger of gangrene. When once a fractured limb has been "put up," the less it is disturbed the better. No good can possibly come from meddling with it, but a great deal of pain must necessarily result to the patient. The Surgeon should always bear in mind that, in the treatment of a fractured bone, he can do nothing to promote its union, beyond placing it in a good position. Nature solders the bone together; and the less the Surgeon interferes the better. But it is requisite to examine the limb from time to time, and especially about the second or third week, when bony union is commencing, in order, if necessary, to correct displacement. In the earlier stages, supervision is necessary lest the bandage be too tight; and, if the patient complain of any pain or numbness, or if the extreme parts look blue and feel cold, the bandage must immediately be removed; for, though the apparatus may not have been applied tightly, swelling of the limb may come on from various causes, to such an extent as to produce strangulation and gangrene, as I have seen happen in at least three instances, in each of which the limb required amputation (Fig. 166). It is remarkable that the whole of a limb will fall into a state of gangrene in these circumstances with but little pain, and often with very slight constitutional disturbance, the parts having their sensibility deadened by the pressure. Before applying the apparatus in a case of fracture, and as often as it is taken off, it is a good plan to sponge the limb with warm soap and water, to prevent the itching that otherwise may be very troublesome.

Splints of various kinds are used in cases of fracture. Tin, wire, zinc, or

thin sheet-iron, wood, leather, "poroplastic felt," and guttapercha, are the materials usually employed. Gooch's splint, which is made of narrow strips of wood glued upon a sheet of coarse calico, is very useful in many cases, and narrow rods of soft iron surrounded by thick india-rubber tubing, or thick telegraph wire is often very convenient. For some kinds of fracture, special, and often very complicated apparatus, is very generally used; but the Surgeon should never confine himself to one material, or to one exclusive mode of treating these injuries, as in different cases special advantages may be obtained from different kinds of splints. In applying leather, guttapercha, paste-board and poroplastic splints, a pattern should first be made of paper, of the proper size and shape, by which the splint is cut out; the material must then be softened by being well soaked in hot water, or in the case of poroplastic splints by dry heat or steam, and moulded on to the part whilst soft; as soon as it has taken the proper shape, it should, if guttapercha be used, be hardened by being plunged into cold water; paste-board or leather must be allowed to dry on the limb, and poroplastic felt will harden as it cools. The edges may then be feathered, the corners rounded and the interior lined with wash-leather or lint. These splints have the advantage of great durability, cleanliness, and lightness.

When a flat splint is used, not moulded to the part, it should be wider than the limb so that the limb may lie on the splint, and not the splint upon the limb. Whether flat or moulded to the part it should securely fix the two joints connected with the fractured bone; if the thigh, the hip and knee; if the leg, the knee and ankle. The splints must be smoothly covered with pads, which should overlap the edges. It is impossible to keep the fragments perfectly immobile, and in close and accurate apposition, unless these very important points be attended to.

Special Apparatus should be employed as little as possible in the treatment of fractures. It is scarcely ever necessary in simple fractures, and is far more cumbersome and costly than the means above indicated, which are all that can be required. I have no hesitation in saying that a Surgeon of ordinary ingenuity and mechanical skill may be fully prepared to deal successfully with every fracture which he can be called upon to treat, by having at hand a smooth deal plank half an inch in thickness, and a sheet of guttapercha, undressed sole-leather, paste-board, "poroplastic material," perforated zinc, or thin sheet-iron, to cut into splints as required.

To the means above described, some kind of **rigid apparatus,** moulded to the limb, forms an invaluable addition. Although various plans for stiffening and fixing bandages in cases of fracture had previously been employed, it was not till about forty years ago that their full value became recognized, chiefly through the practice and writings of Baron Seutin. Since that time a variety of substances, such as gum and chalk, glue, paraffin, tripolith, and water-glass, have been recommended for the purpose of stiffening bandages, but the two which are practically most useful and have longest maintained their reputation, are the starched bandage and the plaster of Paris bandage. These represent two different types of fixed apparatus. The starched bandage is applied over a mass of cotton-wool, which is firmly compressed during the application of the apparatus, and thus exerts a gentle uniform elastic pressure, holding the fragments in position. The plaster of Paris bandage takes an actual cast of the

injured limb; it is not intended to exert any pressure—in fact if applied in such a way as to do so, it is a dangerous application.

The Starched Bandage.—The following is the mode of applying this apparatus which I have found to answer well. The whole limb is enveloped in a layer of cotton-wool, thickest along and over the osseous prominences; this, being elastic, accommodates itself to the subsequent diminution in size of the limb, and keeps up more equable pressure. Over the cotton-wool are laid splints of thick, coarse pasteboard properly shaped to fit the limb, and then softened in hot water. The pasteboard should be doubled and torn down, *not* cut, as in this way the edges are not left sharp. If great strength be not required, as in children, or in some fractures of the upper extremity, a few strips of brown paper, well starched, may be substituted for the pasteboard. A bandage saturated with thick starch is now firmly applied; and lastly, this is covered with another dry roller, the inner sides of the turns of which may be starched as it is laid on.

The bandages must be applied with sufficient force to compress the mass of cotton-wool surrounding the limb. There is no danger of constriction if enough wool be used. No bandage must on any account be applied beneath the pasteboard splints. Both the pasteboard splints and the starched bandage

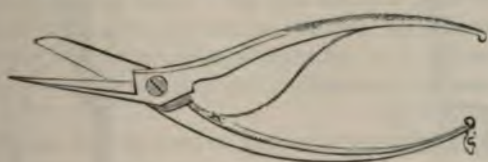

Fig. 162.—Seutin's Pliers.

should always include the joints immediately above and below the fracture, so that complete immobility of the fragments may be secured. During the application of this apparatus, extension must be kept up by an assistant, so as to hold the fracture in position; and, until the starch is thoroughly dried—which usually takes from thirty to fifty hours—a wooden splint may, if necessary, be applied to the limb. The drying of the starch may be hastened by the application of hot bottles. After the bandages have become quite dry, the patient may be allowed to move about on crutches, taking care, of course, to keep the injured limb well slung up, and not to bear upon it, or to jar it against the ground (Fig. 164). In the course of about three or four days after its application, as the swelling caused by the fracture subsides, the apparatus will usually be found to have loosened somewhat. In these circumstances, it must be cut up with Seutin's pliers, such as are represented in Fig. 162, or French vine-dresser's scissors, which are perhaps more durable. This section must be made up the front of the limb, care being taken not to injure the skin in so doing. If the fracture be so far consolidated that the limb can be handled without fear of displacing the fragments, the splint may be completely removed, and its edges pared, about three-quarters of an inch being taken from each. The cotton-wool is then cleaned out from its inside, a fresh layer is wrapped round the limb, and the apparatus re-applied by means of an unstarched roller or tapes. If the fracture be too recent to allow of this, the edges must be pared without removing the splint from the limb,

and changing the cotton-wool must be deferred to a later period. If the fracture be compound, a trap may be cut in the apparatus opposite the seat of injury, through which the wound may be dressed (Fig. 163).

The advantages of the starched bandage in the treatment of fractures consist in its taking the shape of the limb accurately, and maintaining it by its solidity: in its being light, inexpensive, and easily applied, with materials that are always at hand. It secures complete immobility of the limb in the position in which it dries. The joints in the neighbourhood of the fractured bone are securely fixed, and the perfect adaptation of the apparatus to the inequalities of the limb prevents all movement. Thus it maintains accurately

Fig. 163.—Starched Bandage: Trap left for Dressing Wound.

Fig. 164.—Starched Bandage applied to Fractured Thigh.

not only the length but the normal curves of the limb. From its lightness it possesses the great advantage, in fractures of the lower extremity, of allowing the patient to move about upon crutches during nearly the whole of the treatment; thus preventing the tendency to those injurious consequences that often result from prolonged confinement to bed; and, by enabling the patient to keep up his health and strength by open air exercise, facilitating the consolidation of the fracture. In addition to this, the patient will often be able to carry on his business during treatment. By employing the starched bandage in the way just described, I scarcely ever find it necessary to keep patients in bed with simple fractures of the leg for more than from four to seven days, thus saving much of the tediousness and danger of the treatment.

In several hundreds of fractures of all kinds, I employed Seutin's plan soon after its introduction into this country, putting the limb up in the starched

apparatus *immediately* after the reduction of the fracture. I found the practice a safe one, even in fractures of the thigh ; so much so, that at the Hospital I for some time rarely used any other plan of treatment. The moderate pressure of the bandages, aided probably by the great evaporation from so extensive and thick a mass of wet starch, seemed to take down the swelling most effectually. Thus the patient was often able to leave his bed about the third day after the injury, when the fracture was in the leg or ankle, and about the sixth when it was the thigh that was broken.

Further experience, however, showed that the fractures to be treated in this way require selection. A simple fracture of one bone of the leg or of both bones, without comminution or marked displacement, or great extravasation of blood, may safely be put up immediately in the starched bandage or any other rigid apparatus. In more severe cases it is better to wait till the end of the first week or the beginning of the second before applying the starched bandage. In fractured thighs also it is better to allow a certain degree of consolidation to take place, otherwise from the difficulty of completely fixing the hip-joint by means of a starched bandage some return of displacement may take place. The best time for its application in these cases is about the end of the second week. Care must be taken to enclose the foot in the splint, otherwise rotatory displacement outwards may occur. By this means I have obtained the most satisfactory results in cases of fractured thigh ; patients having frequently been cured without any appreciable shortening, with the preservation of the natural curve of the bone, and without confinement to bed after the second week.

Plaster of Paris may be used in the treatment of fractures in any one of the four following ways :—

1. The *simple plaster bandage* is thus applied : A coarse muslin bandage is first prepared by rubbing some fresh plaster thoroughly into its meshes. The very best plaster must be used, and it must be quite fresh ; if it has been exposed even for a few days in a damp place it will be practically useless. The bandage is then loosely rolled up, a little more plaster being sprinkled between its turns as this is done. The necessary number of bandages having been got ready, the limb must be prepared. This is done in various ways. Formerly at University College Hospital we used merely to grease the limb and apply the plaster directly to the skin. This had the disadvantage of being difficult to remove. The better plan is to apply a dry flannel bandage smoothly to the limb. The bandage must be made of elastic Welsh flannel and must not be drawn more tightly than is necessary to prevent creasing, otherwise it might cause constriction of the limb. A prepared plaster bandage is then placed, end upwards, in a basin of water deep enough to cover it completely. It is then taken out and squeezed to get rid of the excess of water and smoothly rolled over the flannel. *The bandage must on no account be pulled.* It is to be laid smoothly on the limb without making reverses. In order to avoid these, it may be cut whenever necessary. The muslin bandage, it must be remembered, is used merely as a convenient means of applying the plaster and to give toughness to it when it is set ; a plaster bandage must on no account be used to exert pressure, or when it sets it may cause serious constriction of the limb. As the bandage is applied it must be rubbed with the hands to squeeze out any air that may have got between the turns, and if necessary, some plaster made into a cream with water may be rubbed in with the hand. If it be

thought necessary to strengthen the apparatus at any point, this may be done by laying on strips of the plaster bandage, which must be secured by a final circular turn; or strips of thin tin-plate, perforated zinc, or telegraph wire, may be applied between the layers of bandage. In an ordinary case about three layers of bandage will be required. Some Surgeons prefer to use cotton-wool instead of the flannel; this however necessitates pulling the bandage, which is never a safe proceeding with plaster. Moreover, cotton-wool after a few days becomes packed together inside the plaster case, which no longer fits accurately. If a mass of cotton-wool be made to surround the limb it is better to apply either the starched bandage and paste-board splints or the silicate of soda bandage, both of which can be cut up and removed and repacked without destroying the splint.

Good plaster hardens in the course of about eight minutes, and, as it dries, it forms a solid, hard, and light casing to the limb, affording excellent support to the fracture. The setting of the plaster may be retarded by the addition to it of solution of borax. Thus a solution of 1 part to 12 of the water used will retard the setting fifteen minutes; and 1 to 8 will retard it fifty minutes, and so on. The plaster bandage possesses the advantage over the starched apparatus of being lighter and less cumbersome, and especially of hardening very quickly, so that not only can the limb be easily held in position till the plaster is firm, but the patient can be immediately moved to any distance after the setting of the fracture.

The plaster of Paris bandage may be applied to any fracture after the swelling has subsided, and it may be put on immediately in all cases in which, from the nature of the injury, but little swelling is to be expected, such as fracture of the metatarsal or metacarpal bones, or fracture of one bone of the leg. If applied when the limb is swollen the splint soon becomes loose as the swelling subsides. After its application the exposed parts of the fingers or toes must be carefully watched, and if they should become blue or cold the apparatus must be at once removed.

2. Neudörfer is a strong advocate for the employment of the plaster of Paris bandage. He recommends that it should be applied immediately (on this he lays great stress), in the following way. Compresses of linen, or of lint, are dipped in plaster of Paris of the consistence of a common poultice. These are then placed longitudinally on the limb, first on the upper, then on the under part. A few turns of a bandage keep them *in situ* till the plaster is set. To prevent the contiguous edges from adhering, they are slightly greased, or a strip of greased lint is put between them. Neudörfer sometimes places pieces of thin wood, like veneer, lined with cotton-wool, next the skin; over these the bandage, saturated with the plaster, is applied by circular turns in the usual way.

3. The method of applying the plaster apparatus, as practised in the Bavarian army during the Franco-German War, is as follows. Two pieces of flannel, twenty inches broad, are stitched together down the middle for a length equal to that of the leg; beyond this both are cut through in the same line for the length of the foot. The flannel is placed under the limb, so that the seam reaches from the ham to the heel. The sides of the inner piece are brought together over the leg, and fixed in front, and along the sole, by hare-lip pins (bent at a right angle, so that they may be easily extracted afterwards), and thus a closely fitting stocking is formed. The sides of the inner piece are

then brought forwards and cut, so that each may overlap the middle line of the leg and sole by three-quarters of an inch. The limb is then laid on one side: and while the outer piece of flannel is held back, a layer of plaster of Paris of the consistence of thick cream is spread evenly, to the thickness of half an inch, over the inner piece, and made to pass quite to the seam behind, and the line of junction of the sides of the inner piece in front. The outer piece is pressed over this before it sets, and should just reach the middle line in front and along the sole. When this has set, the limb is turned over, and the process is repeated on the other side. The pins may now be removed. The seam serves as a hinge; and when the whole has set, the splint may be taken off, the edges of the plaster trimmed, and those of the inner piece of flannel cut so as to leave sufficient to turn over and stitch down on the outer piece. The splint is then readjusted and fixed by a bandage (Fig. 165).

4. Another mode of applying the plaster, which has been recommended by Croft, of St Thomas's Hospital, will be found very useful. Some common

Fig. 165.—Bavarian Plaster Splint.

house flannel or old blanket is cut into the form of lateral splints, and of such a size as almost to meet round the limb. Two of these must be cut for each side of the limb. The one which is to lie next the skin is then placed upon a table, with its inner side downwards; the other is well soaked in plaster of Paris and water of the consistence of thick cream, and immediately applied to it. The two are then taken up together and placed upon the limb; those for the opposite side having been prepared in the same way are quickly applied, and the whole surrounded by a muslin bandage. The limb is to be held in position while the plaster sets. When all is solid the muslin bandage can be cut down the front of the limb, and the apparatus taken off whenever it is desirable to examine the fracture.

In all cases in which the plaster bandage is used, there is danger of unsafe constriction of the limb after the setting of the plaster, either in consequence of the apparatus having been applied too tightly, or of the inner bandage, which has been directly applied, becoming tightened by the swelling of the limb within it. Hence great care must be taken for several days after the application of the apparatus, to watch the limb carefully, and if signs of constriction come on, such as pain, coldness, numbness, and œdema of the toes or fingers, it should be immediately cut up, re-adjusted or removed. No time should be lost in doing this, as the limb may have become gangrenous in patches, with little suffering to the patient or constitutional disturbance.

The Silicate of Soda or Water-glass Bandage is another very useful form of rigid apparatus. The materials required are a solution of silicate of

soda of the consistence of syrup, which can be purchased ready prepared and keeps well in a stoppered bottle, and some thin bandages. The bandages are to be thoroughly soaked by being drawn through a sufficient quantity of the solution in the bottom of a basin, and then rolled up again. A thick padding of cotton-wool is then put round the limb, and the silicate bandage applied directly upon it. No pasteboard splints are used, and about four or five layers of bandage will be required. It dries in from 12 to 24 hours, and makes a clean, firm, light case, which can be cut up and treated like a starched bandage.

In the treatment of ordinary simple fractures of the shafts of long bones, the following are the chief points that require attention :

1. To effect reduction at once, and with as little disturbance of the limb as possible.

2. Not to apply any calico roller to the part of the limb in which the fracture is situated, nor under the apparatus.

3. To line or pad the apparatus uniformly.

4. To include and fix in the apparatus the two joints connected with the injured bone.

5. To disturb the apparatus as seldom as possible.

6. To use starched pasteboard or plaster apparatus, when practicable, in preference to any more special form of appliance.

Accidents and Complications during Treatment are liable to occur, some of which are general and others special. Amongst the complications to which cases of fracture are liable, in common with a ll others, are tetanus and erysipelas, but these rarely follow simple fracture, and require no further notice here.

Traumatic Delirium, or **Delirium Tremens,** is by no means an uncommon complication, and is always serious. The general treatment has already been given (p. 309). Locally, as soon as the symptoms show themselves, the fracture must be firmly supported by splints or by a starched or plaster of Paris bandage. The injured limb must be slung from a cradle, and on no account tied to the bed. This, as a rule, fixes only the lower fragment, while the upper works about during the struggles of the patient, and may cause the most serious mischief.

Fat Embolism.—If the lungs of a patient who has died shortly after a severe accident crushing one or more bones be examined microscopically, after staining with osmic acid, a certain number of the capillaries, and perhaps some of the terminal arteries, may be found plugged with liquid fat. The appearances are very characteristic, the fat being stained black by the osmic acid; and it is easy to recognise the plugs in tortuous capillaries surrounding the air-vesicles or in the small branching arterioles. If the remaining organs be examined, similar embolic plugs may be found in all parts of the body and in the nervous centres. In the kidney the loops of vessels in the Malpighian vessels are frequently found distended with fat. Experimental enquiry into the subject has led to the following conclusions. If liquid fat or oil be in any way set free amongst the tissues it may find its way into the circulation either by means of the lymphatics or by the veins. If injected into the healthy subcutaneous tissue it enters the circulation more slowly than from the pleura or peritoneum. Pressure favours the process ; thus, if the fat of the medulla of a long bone be broken down and a laminaria tent inserted, fat embolism is

speedily induced. In many surgical injuries we have the conditions necessary for fat embolism. In fractures crushing the medulla of a bone a large number of the fat-cells of the marrow are broken up and the liquid fat set free; and the same may happen in violent contusions of the subcutaneous tissue in fat subjects, and in contusion or laceration of a fatty liver. At the same time the pressure of extravasated blood and of inflammatory exudation favours the entrance of the fat into the circulation. Fat embolism has also been met with in acute inflammation of the marrow of a bone, and in diffuse gangrenous inflammation of the subcutaneous areolar tissue.

Fat embolism as a complication of simple fracture may occur within the first twenty-four hours, as the direct effect of the injury, or on the second or third day, or as the result of the inflammatory exudation pressing on the injured medulla or adipose tissue. The symptoms caused by it are somewhat doubtful. Riedel and Scriba state that the fat is eliminated by the kidneys, and will, in a very large proportion of fractures of long bones, be found microscopically in the urine about the third or fourth day. At a later period, from the tenth to the fourteenth day, it is often met with again, a fact which Scriba attributes to the dislodgment of the emboli from the lungs and other viscera and their elimination by the kidneys. A trace of albumen and some casts are sometimes met with at the same time. These appearances need not be accompanied by any constitutional symptoms. Should the quantity of fat which enters the circulation be very large, it is supposed to be capable of causing grave or even fatal symptoms, of which, according to Scriba, the following are the most characteristic: slight lowering of temperature, dyspnœa, occasionally slight hæmoptysis, and in extreme cases, fatal collapse, spasms or localized paralysis, ending in coma and death. Scriba is of opinion that whenever fat embolism proves fatal it is from obstruction to the vessels of the brain, and that the interference with the pulmonary circulation is never sufficient to cause death. That death does occur in some rare cases after simple fractures with some or all of the above-mentioned symptoms is certainly true, and that fat embolism can be found *post mortem* is equally certain; but that it is the cause of the symptoms is doubted by Cohnheim and many authorities, as experiments have shown that very large quantities of fat can be injected into the circulation of animals so as to cause most extensive embolism without being followed by death or even any serious symptoms.

In cases of septic inflammation following a compound fracture or a severe laceration of adispose tissue, the fat emboli may become impregnated with the septic poison, and thus set up inflammation wherever they lodge. The emboli from subcutaneous injuries are said occasionally to give rise to hæmorrhagic infarcts around the point at which they are arrested, and in some cases to cause œdema of the lung by extensive obstruction to the circulation; but being perfectly unirritating they never set up inflammation.

No treatment has yet been suggested for fat embolism.

In fractures of the lower extremity occurring in old people, there is a great tendency to **Hypostatic Pulmonary Congestion**, as a consequence of long confinement in the recumbent position; these fractures often prove fatal in this way. The use of the starched bandage, by enabling the patient to move about, is the most effectual preventive of these accidents.

The treatment of the more general accidents presents nothing that need

detain us here; but those that are more special and peculiar to fractures require consideration.

Crutch palsy of the hands and arms may occur as the result of compression of the brachial nerves against the pad of the crutch. The whole plexus, or only one of its component nerves, as the musculo-spiral or ulnar, may be affected. The remedy is obvious: it consists in the discontinuance of the use of the crutch, and if need be, the employment of electricity to the palsied muscles.

Spasm of the Muscles of the Limb, owing to the irritation produced by the fragments, is often severe so long as the fracture is left unreduced; but usually ceases after reduction, and the maintenance of the fracture in proper position. If the spasm be dependent upon nervous causes, full doses of opium will not unfrequently afford relief. In some cases it is of a permanent character, producing considerable displacement of the fragments. In these circumstances, division of the tendons has been recommended; but this practice appears to be an unnecessarily severe one, and may certainly most commonly be avoided by attention to the other plans of treatment which have been suggested.

Œdema of a broken limb may occur from several causes, viz., over-tight bandaging, dependent position, pressure of extravasated blood, venous thrombosis or inflammatory effusion. It is of no great moment in itself, but may be of consequence as indicative of approaching gangrene. Relief may usually be afforded by loosening the bandages, and elevating the limb.

The œdema, which is often very persistent after the cure of the fracture, is best relieved by diligent friction, douching, bandaging, and attention to position.

Considerable Extravasation of Blood is frequently met with in cases of simple fracture, causing great swelling and tension. The blood is in most cases readily absorbed; and the Surgeon should never be tempted by any feeling of fluctuation to open it, as he would thereby convert the simple into a compound fracture. In some of the cases of extensive extravasation, the limb appears to relieve itself of the serous portion of the blood effused, by the formation of large bullæ or blebs, which may be punctured, or else allowed to burst and subside, without any material inconvenience. This extravasation very rarely, indeed, runs into abscess; if it do, it must of course be opened, and treated upon antiseptic principles. If deeply effused it may lead to gangrene, by the compression which it exercises on the vessels.

Splint sores are easily produced if an imperfectly padded splint be allowed to exert undue pressure upon a superficial bony point, such as the internal condyle of the humerus or either malleolus. Under these circumstances sloughing of the skin may be caused with remarkably little pain. This troublesome complication can usually be avoided by a careful arrangement of pads around any bony prominences covered by the splint; when once formed, the resulting sore must be treated on general principles.

Gangrene not directly due to injury of the main vessels of the limb occurring as a complication of simple fracture, is a most serious mischance, and one as to which it is difficult for the Surgeon to exonerate himself from blame. But he is not always in fault. It may arise from causes residing in the limb. It may be contributed to by the negligence of the patient in not drawing the Surgeon's attention to early symptoms, after having been duly

warned. Gangrene of the limb (Fig. 166) may occur after simple fracture as the result (1) of tight bandaging; (2) of the swelling of the limb and compression of the vessels consequent upon extravasation of blood; or (3) of inflammatory infiltration causing strangulation within a bandage that has been at first but lightly applied. *Gangrene is almost invariably the consequence of the pernicious practice of applying a bandage directly to the limb under the apparatus.* I have never known gangrene to occur after fracture except when this had been done, since it is much more likely to occur in those cases in which the fracture is treated by the unskilful application of an immovable apparatus, whether of starch, plaster of Paris, or other similar material, than when splints are used. Indeed, if the splints be well padded, and no bandage be put on under them, it is almost impossible that an amount of constriction can be exercised on the limb sufficient to interrupt the circulation through it. I believe that this accident would rarely, if ever, occur, if the Surgeon were to avoid the direct application of a bandage to the limb, however lightly, in fractures, more particularly in children. The danger of strangulation is

Fig. 166.—Gangrene of Forearm and Hand from Tight Bandaging.

especially great if, as happened in the case from which the accompanying cut (Fig. 166) is taken, the limb be bandaged whilst straight, and then flexed, as the bandage will then cut deeply at the flexure of the joint, and will certainly destroy the vitality of the part, if not of the whole limb. The pressure of an axillary pad, used in many fractures of the upper extremities, may also tend to the supervention of gangrene by interfering with the return of blood through the axillary vein. Hence in these cases the fingers should be examined daily. Even if no *direct* bandage have been applied, the apparatus should at once be removed, and the limb examined if any appearances of congestion, such as blueness, coldness, œdema, or vesication of the fingers or toes, show themselves, or even if the patient merely complains of slight uneasiness. If it be left on beyond this, gangrene will probably set in, slow strangulation going on under the bandages without much, if any, pain. Vesications of very large size will often occur, as a consequence of the raising of the cuticle by the transuded serum of extravasated blood. It is only when associated with coldness of the limb, a dusky purple hue, and a putrescent odour, that they are indicative of gangrene. An excellent plan of judging of the activity of the circulation in a fractured limb, after it has been put up, is to leave the ends of the fingers or toes uncovered by the bandage; when, by pressing upon one of the nails, the freedom of the circulation may be ascertained by noting the rapidity

with which the blood returns under it. A question of great medico-legal importance occasionally arises in connection with gangrene of the limb after simple fracture. It is this—Is the gangrene owing to over-tight, and consequently negligent, bandaging by the Surgeon, or to passive strangulation by inflammatory swelling of the limb under bandages not originally too tightly applied? The diagnosis of the two conditions on which the answer is dependent is as follows: 1. When a bandage has originally been too tightly applied, the patient will suffer severely for several hours, the pain being felt immediately after the application of the apparatus. On loosening the bandage, the pain ceases. When removed, if gangrene have set in, the skin will be found pale where the roller has been applied—the limb being compressed and small at this part, and marked with imprints at the edges of the turns of the bandage—whilst it is greatly swollen and congested at the fingers or toes beyond the bandage; these parts being also cold, purple, and vesicated. 2. When the strangulation occurs from inflammatory swelling of the limb, the whole member is equally swollen; it is red and blue, hot in parts, cold and sphacelated in others. It never becomes uniformly gangrenous, but deep infiltrating abscess and localised sphacelus form.

Treatment.—When a bandage or apparatus appears to be exerting painful or dangerous pressure, it must at once be removed. Should the circulation of the limb have been interfered with, friction with oil in an upward direction should be employed.

If gangrene have unhappily already occurred, the treatment will depend on the cause, and on the condition of the limb. If it be the result of self-strangulation of the limb, by swelling under the bandage, and if the parts be found to be red, swollen, and infiltrated, free incisions should be made, and some efficient antiseptic dressing applied. If, notwithstanding this, suppuration follows, with deep infiltration of the cellular tissue, and sloughing of the skin and muscles, the choice lies between amputation and the preservation of a limb that will be withered, contracted, and useless.

If the gangrene be the result of direct strangulation by an over-tight bandage, as in Fig. 166, there is no resource left but amputation above the seat of constriction.

After a fracture has united, the limb will sometimes be found to be **shortened.** This may of course be due to unskilful management on the part of the Surgeon, to want of proper coaptation of the fragments, or to the patient being allowed to bear on the limb whilst the callus is still soft and pliable. But it may have existed before the accident, and be natural to the patient and in no way a consequence of the accident.

Inequality in the length of the corresponding limbs on opposite sides of the body, independently of any accident or disease, is not very unfrequently met with. It may exist to a considerable extent without the patient being aware of it. I have several times found the spinal curvature of young adults to be due to one lower extremity being from $\frac{3}{8}$ to $\frac{3}{4}$ of an inch shorter than the other, thus causing obliquity of the pelvis. It is usually the right limb that is the longer, but in some cases the left is not only longer but also larger. Of 512 boys examined by Morton, of Philadelphia, appreciable differences between the two limbs were found in 271 cases, from $\frac{1}{8}$ of an inch in 91, to as much as $1\frac{3}{8}$ inch in one. The bearing of these facts on the cause of shortening of limbs after the treatment of fractures, and the question of malpraxis, is evident.

The shortening of a limb in a growing child after fracture may also be due to its necessary confinement in splints, and to the inaction causing interference with its growth, or to implication of an epiphysial cartilage, and not to the fracture having been inaccurately adjusted.

Complicated Fractures.—Fractures may be **complicated** with various important local conditions. Extravasation of blood into the limb, from a wound of some large vessel, may go on to so great an extent as to occasion strangulation of the tissues; if not checked by position and cold applications, it may give rise to gangrene, and demand amputation. In other cases, again, the soft parts in the vicinity of the fracture may be contused to such a degree that they rapidly run into slough, thus rendering it compound; or a wound may exist, not communicating with the broken bone, but requiring much modification of treatment, and special adaptation of apparatus.

One of the most serious complications is **Injury of the Main Artery** of the limb opposite the seat of fracture. This is, however, far less common than might be supposed. Excluding complete smashes of the limb, Bruns, with considerable labour, has collected 87 cases, 63 in simple and 24 in compound fractures. The accident is far more common in the lower than in the upper limb, 68 of the cases occurring in the former and 19 in the latter. Amongst the cases were 24 of injury of the popliteal artery, 21 of the anterior tibial, 13 of the posterior tibial, 9 of the brachial, 8 of the axillary, 4 of the femoral. Amongst the other arteries rarely injured are the subclavian in fracture of the clavicle, the sciatic in fracture of the pelvis, the peroneal and the nutritive artery of the tibia. In 68 cases the exact nature of the injury is mentioned. In 24 the artery was completely ruptured, in about half the cases by the same violence that caused the fracture; in 26 the artery was partially divided; in 7 it was contused and subsequently occluded by thrombosis; and in 11 it was compressed or nipped by the fragments. The symptoms will depend on the nature of the injury. **If the vessel is merely compressed or contused** there will be no extravasation of blood, and the nature of the injury is indicated by loss of pulsation in the branches beyond the injured point and coldness of the limb. **If the artery is completely torn across** it commonly soon ceases to bleed, being closed in the way already described (p. 407), but before this occurs a considerable amount of blood may have been poured out subcutaneously. The symptoms in such a case would be great distension of the limb, ceasing to increase after a short time, with absence of pulsation beyond the injured point. The chief danger in these cases is the supervention of gangrene, a termination more likely to follow when the fracture is the result of direct violence crushing the soft parts as well as the bone, than when the artery has been injured by the displaced fragments in a fracture by indirect violence, the surrounding tissues being but little contused. The *treatment* in these cases will depend on the nature of the injury. If the artery is merely compressed by a displaced fragment, reduction of the fracture may restore the circulation. If it is occluded, with little or no extravasation and but slight bruising of the soft parts, so as to justify a hope that the collateral vessels are not greatly injured or pressed upon, an attempt should be made to save the limb. It should be placed in the best possible position and warmly wrapped in cotton-wool. Splints and bandages must as far as possible be avoided, lest the collateral circulation be interfered with by their pressure. If there has been great extravasation of blood, the pressure of which would

evidently prevent the establishment of the collateral circulation, gangrene is inevitable, unless this can be relieved. If the fracture is from indirect violence, and the soft parts are but little contused, an attempt might be made to relieve the pressure by free incision and evacuation of the blood clot, if this can be done with efficient antiseptic precautions. If decomposition occurred the septic inflammation and swelling would almost inevitably so far interfere with the circulation as to cause gangrene, and necessitate amputation under very unfavourable circumstances. If, therefore, there is any doubt about preventing putrefaction, or if the soft parts are much bruised, as in a fracture by direct violence, or if after an attempt to save the limb gangrene has set in, amputation above the seat of injury is our only resource.

If the artery be only partially ruptured or be torn across and not closed, the hæmorrhage will continue subcutaneously. In the great majority of cases this leads to the formation of a so-called diffused traumatic aneurism. The symptoms consist in the rapid formation of a uniform elastic tense swelling, in which there may be obscure pulsation, though this is often wanting. On laying the hand on the swelling a thrill may be perceptible. According to V. Wahl, a bruit will be heard in all cases in which the artery is merely punctured or partially divided, but it is wanting when the vessel is completely torn across. There is cessation of pulsation in the artery with coldness and numbness of the limb beyond the injury. Some blood usually finds its way into the limb by the collateral vessels even if the main artery, as the femoral or brachial, be wounded, but the pressure of the extravasated blood hinders the venous return and the limb soon becomes of a dusky purple colour. There is always severe tensive pain, sometimes throbbing. If it be one of the tibial arteries that is wounded the swelling may cease to increase, the circulation in the arteries of the foot may return after a day or two, and the coldness and numbness may diminish, but such a result is rare. If it be the popliteal that is injured, no such amelioration will take place, but the arterial extravasation in the ham will increase, the circulation will become more and more impeded, and gangrene will result. Much less commonly the traumatic aneurism may develop slowly from eight days to a month after the accident and then it assumes the circumscribed form. In these cases the wound has probably been very small, or possibly the external coat may not have been torn at the time of the accident but has yielded subsequently.

In the **treatment** of subcutaneous arterial extravasation complicating fracture the Surgeon has three alternatives.

1. The case may be treated as one of open arterial wound, the tumour laid open, and the vessel ligatured at the seat of injury. The objections to this treatment are, that a large cavity is opened, which, if it suppurate, will give rise to the most serious constitutional disturbance, the fracture being rendered a compound one of the worst kind, complicated by the great extravasation of blood amongst the surrounding parts. Securing the artery is, moreover, under any circumstances extremely difficult, and even uncertain. In the present day the dangers of suppuration and sloughing following in the cavity may be greatly reduced, if not abolished, by the employment of some efficient mode of antiseptic treatment, and the exposure of the artery can be facilitated by the bloodless method of operating. If the means of treatment at the command of the Surgeon are such that he may hope effectually to prevent the injurious consequences of exposing the fracture to the air, there is no reason why he

should deviate from the acknowledged rule of Surgery, to tie the wounded vessel at the injured spot.

Amongst the cases tabulated by Bruns are the following treated by this method :—Axillary artery, 3 cases, 2 deaths ; brachial, 2 cases, 0 deaths ; femoral, 1 fatal case ; anterior tibial, 7 cases, 5 cured, 1 amputated, and 1 death ; and posterior tibial, 2 cases, 1 amputated and 1 died. In two of the cases of the anterior tibial the vessel could not be tied, and the wound was plugged successfully. In the successful axillary case the aneurism did not appear till the eighth day.

2. The circulation through the main artery may be arrested by compression or by ligature on the proximal side. Bruns records five cases in which compression was attempted. Of these three were successful. In one the artery wounded was supposed to be the circumflex at the shoulder ; in the two other cases the injured vessel was the anterior tibial; but in both the aneurism was of small size and slow formation. Compression failed in a circumscribed aneurism of the brachial, and still more markedly in a large diffuse aneurism of the femoral artery. Proximal ligature is recorded in seven cases. In one the subclavian was tied for a diffuse axillary aneurism with a fatal result ; in one the axillary was tied for a circumscribed aneurism of the brachial ; in one the femoral was tied successfully for a popliteal aneurism, which appeared four days after the fracture, and in one for a diffuse popliteal aneurism, fatal from gangrene ; and in three cases, only one of which was really diffused, the femoral was successfully ligatured for aneurism of the posterior tibial.

3. Amputation may be performed. This severe measure need not be carried out at once. The Surgeon may wait a day or two and watch the progress of events. If he find that there is no sign of restoration of pulsation in the vessels beyond the injury, that the coldness and numbness of the limb continue to increase, and, in fact, that gangrene is impending, then the sooner he amputates the better for the patient's safety. If the artery have been tied, and gangrene result, the limb ought at once to be removed.

To sum up : It would seem from the evidence before us that if one of the larger vessels, such as the femoral, popliteal, axillary, or brachial, be wounded in a fracture, and a rapidly spreading extravasation form at once, the best chance for the patient lies in following the ordinary treatment of subcutaneous arterial extravasation, and attempting to secure the bleeding vessel at the injured point. In such cases compression is inefficient, and proximal ligature wil probably be followed by gangrene. If the vessel cannot be found owing to the laceration aud displacement of the surrounding structures, or if the bones are much comminuted and the soft parts crushed, amputation above the seat of fracture is the only resource. If the aneurism develops slowly and tends to assume a circumscribed form, compression or proximal ligature offers a good prospect of success. In wounds of the arteries of the leg, if the extravasation be not increasing with dangerous rapidity so as to threaten gangrene of the limb, there can be no reason why the effects of pressure upon the femoral artery by means of Carte's or some other appropriate compressor should not be tried before proceeding to more severe measures. If this should fail to cure, and the aneurism should yet show some tendency to become circumscribed with return of pulsation, warmth and sensibility in the parts beyond, proximal ligature of the femoral artery in Scarpa's triangle offers a good prospect of success ; but should the swelling continue to increase and the foot remain

cold, no time should be lost in cutting down upon the injured vessel, a proceeding which has been attended with a very considerable amount of success, even before the introduction of antiseptic treatment and bloodless surgery. If the vessel cannot be tied it may possibly be seized in forcipressure-forceps, which may be left on for twenty-four or forty-eight hours. Failing this, the wound may be plugged. Amputation should be the last resource.

Venous Thrombosis and Embolism.—Wounds of veins in simple fractures rarely give rise to any extensive extravasation of blood, the rare examples of laceration of the subclavian vein in fractures of the clavicle being almost the sole exception. Thrombosis of the deep veins of a fractured limb, especially of the leg, is, however, probably far from uncommon. When we consider the bruising they must frequently suffer, the readiness with which coagulation takes place in the injured veins, and the interference with the venous flow by the prolonged rest of a fractured limb, it is surprising that extensive thrombosis is not more common. It occurs most frequently in the lower limb, though cases are occasionally met with in the arm. As the thrombosis is almost invariably limited to the deep veins, the only evidence of its occurrence is some œdema of the extremity, and perhaps some fulness of the superficial veins. As long as the patient is confined to bed, the elevated position of the limb and the pressure of the splints keep this œdema within very moderate limits, but when the patient begins to move about the swelling becomes more evident. It is probable that the persistent œdema, which is a not uncommon and very troublesome sequela of fracture of the leg, is due to this cause.

Accidental dislodgment of the clot and embolism of the heart or lungs is a very rare complication of simple fractures. Bruns has, however, collected the records of 35 cases, of which 30 were fatal. Thirty-two of these occurred in fractures of the lower extremity. Only one such case has occurred in University College Hospital in the last twenty years, and in that the patient, who had nearly recovered from a compound fracture of the internal malleolus, was suddenly seized with dyspnœa and great cardiac distress, followed by slight hæmoptysis. The symptoms subsided in a few hours, and recovery took place.

Injuries of Nerves in Simple Fractures.—Nerves may suffer a variety of injuries in fractures of the limbs. They may be bruised by the same force that causes the fracture; they may be crushed, or in rare cases even divided by the sharp edge of a splinter; they may be compressed by a displaced fragment; and they have even been known to become interposed between the broken ends. As the fracture unites, a neighbouring nerve may occasionally become imbedded in the callus, and thus compressed. The most frequent complications of this kind occur in the upper limb, the musculo-spiral, from its intimate relation to the humerus, being peculiarly liable to suffer. The brachial plexus is occasionally injured in fractures of the clavicle and of the upper end of the humerus, the ulnar nerve in fractures of the lower end of that bone, and the external popliteal in injuries of the upper part of the fibula. Other nerves are but rarely affected. The symptoms are those already described in the chapter on injuries of nerves as occurring in consequence of wounds or pressure. If the impairment of function comes on at a later period, during repair of the fracture, it may be concluded that it is due to the pressure of callus. It is wiser, in all fractures in which an injury to a nerve is likely to

occur, to examine for it before applying the splints, otherwise it will be overlooked till the apparatus is finally removed, and it is then impossible to say whether the paralysis is due to an injury at the time of the accident or to the pressure of callus. No *treatment* is required beyond galvanism of the paralysed muscles when the injury is merely due to bruising at the time of fracture. If recovery does not take place spontaneously, and if there is reason to believe that the nerve is divided or surrounded by callus, an operation may be undertaken at a later period. Bruns mentions 30 cases in which such operations have been performed, in 20 of which the musculo-spiral was the nerve affected. In most of these it was necessary to remove the callus surrounding the nerve by means of a chisel. Complete restoration of function followed in 24 cases.

Comminution.—However extensively a bone may be **comminuted,** good union will take place provided the fracture be simple. I have seen the lower end of the femur crushed, as if by a sledge-hammer, into a multitude of fragments; and yet excellent union resulted, the fracture being simple. In such a case as this, if there had been the smallest wound to admit air into the limb, and decomposition of the effused blood had followed, the patient's limb, if not his life, would have been lost. It is, in fact, impossible to over-estimate the advantage of an injury of this kind being *subcutaneous.*

A serious complication of simple fractures consists in the **Implication of a Joint.**—The fracture may extend into a neighbouring articulation, and thus give rise to considerable inflammation; in strumous subjects this may lead to ultimate disorganization of the articulation, requiring excision, which I have several times had occasion to perform in these cases. But in healthy individuals a large articular surface may be traversed by lines of fracture in several directions, without material inconvenience resulting. This we see in impacted fractures of the condyles of the femur or of the lower end of the radius. In several instances of this kind in which I have examined the limb after death, no sign of disease of the part has been manifested beyond a moderate amount of injection of the ligaments; the fractured cartilage being united by plastic matter, and the synovia being clear and free from inflammatory exudation. But, although union of fractures extending into articulations takes place readily enough, it cannot be expected that the patient will recover with as mobile a joint as if the fracture had traversed merely the shaft. In fact, in the majority of these cases, the patient will be left with a joint that is weak, stiff, and painful; and, if in the lower extremity, the limb may be unable to support the weight of the body for some considerable time. Possibly also, in many of these instances, an impaired joint will be left through life, as the necessary and unavoidable result of the injury, though not unfrequently unjustly attributed to negligence and want of skill on the part of the Surgeon. Hence it is a wise precaution for the Surgeon when called to a case of fracture involving any one of the six larger articulations, viz., the shoulder, elbow, wrist, hip, knee, or ankle, to warn the patient that some degree of impairment of the use of the limb will probably result.

In cases of simple fracture occurring in the neighbourhood of, or implicating large joints, passive motion is very commonly recommended at the end of from four to six weeks; I think, however, with Vincent, that it is often apt to do more harm than good, and is seldom required, the natural action of the muscles of the part being fully sufficient to restore the movements of the articulation, with the assistance of friction and douches.

The occurrence of **Dislocation** at the same time as the fracture often causes great difficulty, as it becomes necessary to reduce the dislocated joint before the fracture is consolidated. In several instances of this kind which have come under my care, I have succeeded in reducing the dislocation at once, by putting up the limb very tightly in wooden splints, so as to give a degree of solidity to it, and to permit the lever-like movement of the shaft of the bone to be employed; and then, putting the patient under chloroform, I have replaced the bone without much difficulty. Should the Surgeon have omitted to reduce the dislocation in the first instance, he must wait until the fracture has become firmly united, and then, putting the limb in splints or in starch, he may try to effect reduction, which, however, will then be very difficult.

In addition to the foregoing complications I have met with many others, such as fracture in a limb which is the seat of an **Old Unreduced Dislocation**, or an **Ankylosed Joint**, or in the **Site of an Excised Joint** or in the **Stump of an Amputated Limb.** In such cases union has taken place readily, the splints being necessarily modified in such a way as to adapt them to the altered form of the limb.

Amputation is only required in simple fractures for gangrene either from tight bandaging, the direct effect of the injury to the soft parts, or wound of the main vessels. These complications are very rare, and I have never been obliged to amputate for a simple fracture. No amount of comminution will necessitate the operation if the skin and the main vessels are sound. I have had under my care a man, in whom the condyles of both femora and the left patella were crushed into numerous pieces by a fall from a great height on the knees, the limbs at the seat of the injury feeling like bags of loose fragments of bone; yet, as neither the skin was broken nor the main vessels injured, though both knee-joints appeared to be disorganized, the limbs were preserved, and good union ensued.

COMPOUND FRACTURE.—A compound fracture is one in which there is an open wound leading down to the broken bone at the seat of fracture. Thus the term includes injuries varying in severity from a single fracture complicated by a small punctured wound of the skin made by one of the fragments to a complete smash of the whole limb, such as is made by a railway-train passing over it. Compound fractures therefore include many injuries far more severe than any simple fracture can possibly be; but, in a very large proportion of cases, the injury to the soft parts and the splintering of the bone are no greater than in many simple fractures, the sole difference being that, in the one case, there is a wound by which the causes of decomposition can find access to the decomposable blood-clot and inflammatory exudation surrounding the broken ends of the bone, while in the other they are excluded by the unbroken skin. As a consequence of this, unless special means are taken to prevent it, decomposition sets in, the blood-clot breaks down and is discharged, and the septic matter in the cavity of the wound excites inflammation, reaching the stage of suppuration, in the surrounding tissues. Portions of the bruised muscles and the torn periosteum, which in a simple fracture would either have recovered, or if too severely injured would have been penetrated by wandering cells and absorbed, may perish in consequence of the additional irritation caused by the septic matter and finally be cast off as sloughs. From the same causes portions of the ends of the bones which may

have become denuded of their periosteum, or detached splinters, undergo necrosis. In many cases also the external wound is too small to allow of efficient drainage, and consequently the pent-up septic matter burrows widely in the intermuscular spaces of the limb. If, therefore, the decomposition of the discharges cannot in some way be prevented, a compound fracture is not only far more tedious in its cure than a simple fracture, but infinitely more dangerous. It has to unite by a slow process of granulation instead of the more speedy mode of union already described as occurring in simple fractures. The chief dangers of a compound fracture, however, arise from the decomposition of the discharges. During the first week there may be severe septic fever; the stages of granulation and suppuration are often attended with profuse discharge of pus from the original wound and from abscesses forming amongst the surrounding muscles, maintained for a long time by exfoliation from the ends of the fractured bone. The patient may thus be worn out by the prolonged suppuration and the persistent absorption of the products of putrefaction; or the wound may become the seat of some infective process, and death may occur from septicæmia, pyæmia or erysipelas. In other cases the septic inflammation may spread to the medulla of the bone, causing diffuse osteomyelitis, followed by extensive necrosis, a condition frequently terminating in pyæmia. Thus a compound fracture leads not unfrequently to the eventual loss of life or limb. Besides these dangers, which may be looked upon as indirect, the violence that occasions a compound fracture often shatters the limb to such an extent as to lead to the immediate supervention of traumatic gangrene, to the loss of life by hæmorrhage, or to the certain and speedy disorganization of the limb, as the consequence of the subsequent inflammation.

Union of Compound Fracture.—If the superficial wound heal by the first intention, or if the evil effects of decomposition of the discharges can be prevented, a compound may unite in exactly the same way as a simple fracture. Under other circumstances union takes place more slowly by granulation, just as in wounds of the soft parts healing by the second intention. If the injury of the soft parts be but slight and the drainage good, the first process is an abundant inflammatory exudation from the vessels of the injured tissues. This coagulates, the serum draining away partly by the open wound and partly by the lymphatics, and the fibrin, entangling the white corpuscles in the meshes of its coagulum, forms a layer of plastic exudation which covers the injured soft parts and closes the intermuscular spaces. The exudation is very abundant round the bone, and the swollen and infiltrated periosteum, fused with the neighbouring tissues, soon forms a soft mass surrounding the broken ends, as in a simple fracture. Similar changes occur in the medulla. Then follow the formation of new vessels and the development of granulation-tissue; the wound slowly closes up from the bottom, the broken ends becoming by degrees completely imbedded in the growing granulation-tissue. Finally, ossification takes place. This commences in contact with the bone on each side in the granulation-tissue at the point furthest from the seat of fracture. It occurs without the previous formation of cartilage, even in the lower animals, or at any rate with the development of merely a few irregular islets. The intercellular substance increases in quantity, the cells assume the angular forms of osteoblasts, and then follow the deposit of lime-salts and the development of true bone. The

new bone gradually encroaches on the granulation-tissue, and the fractured ends are surrounded by it. The remaining changes are the same as those in a simple fracture. In cases in which the injury has been more severe and in which the process is complicated by the presence of portions of muscle which have either been directly killed by the violence which caused the fracture, or have perished from the combined effects of the injury and of the irritation of decomposing discharges, or by loose splinters, the process of union cannot take place till these are separated by ulceration from the surrounding living parts and are thrown off. In other cases in which the denuded ends of the bones perish, the process of separation may not be complete for many months after the injury. Under these circumstances the sequestra may be surrounded by a mass of new bone uniting the upper and lower fragments and perforated by openings for the discharge of pus from the granulations lining the cavity in which the dead bone lies, and thus a tolerably firm union may take place long before the wound has healed. This process necessarily, in the great majority of cases, occupies a much longer time than that which is required for the union of a simple fracture. The majority of compound fractures, however, unite without the occurrence of necrosis.

Question of Primary Amputation.—The first question that presents itself in a case of compound fracture is, whether the limb should be removed, or an attempt be made to save it. It is of great importance to settle this point at once; for, if amputation be determined upon, it should be done with as little delay as possible, there being no period in the progress of the case so favourable for operation as the first twenty-four hours.

That primary amputations are often fatal, especially when practised near the trunk, cannot be urged as an argument against their performance, as recourse should never be had to *primary* amputation unless it is evident that the patient's life must in all probability be sacrificed by an attempt to save the limb. In determining the cases in which immediate amputation should be performed, much must be left to the individual judgment and experience of the Surgeon. One will attempt to save a limb which another would condemn. But he must bear in mind that, though it is imperative to do everything in his power to save a limb, yet the preservation of the patient's life is the main point, and that course is the proper one which offers the greatest prospect of effecting this. A wise conservatism is much to be applauded, but decision in determining the expediency of amputation is equally characteristic of a good Surgeon. He must consider, not only the nature and extent of the fracture, but the age, constitution, and habits of the patient: and though he may be guided by those general rules which have already been laid down at pp. 338 and 358, when treating of amputation in contused wounds and in gunshot injuries, yet he will often show more wisdom in departing from the letter of the law in making a successful effort to save a limb, which, by strict surgical precepts, would be condemned; or in attempting to preserve the patient's life, by sacrificing a limb that is not injured to a degree that would usually be considered to justify amputation.

1. It may be laid down as a general rule to which there are few exceptions, that all compound fractures, the result of *indirect* violence, in which the wound is made by the fragments of the broken bone, should be saved, provided the main vessels of the limb are uninjured.

2. Fractures by *direct* violence in which the same force injures the soft

parts and breaks the bone, are, as a rule, less favourable. In such cases there is often *much laceration of, and extravasation into, the soft parts.* The integuments may be stripped off, portions of the muscular bellies may protrude, and the planes of areolar tissue between the muscles of the limb may be torn and infiltrated with blood. Injuries of this kind occurring in the lower extremity always necessitate amputation. In the upper limb, even after very extensive injuries of this kind, the limb may often be saved, unless the bones be greatly comminuted. The danger of the operation in these cases does not depend upon the degree of injury to the soft parts and bones, but upon the proximity of the fracture to the trunk (see pp. 86 and 361). Amputation of the thigh high up for fracture of the femur is very rarely followed by recovery.

3. The complication of a compound fracture with the **Wound of a Large Joint** is always serious, but does not in itself necessitate amputation, provided the patient be of sound constitution and be placed in such circumstances that efficient antiseptic treatment can be carried out and perfect rest and drainage maintained. If there be much crushing or splintering of the bones, with laceration of the soft parts, operative interference becomes necessary. In the lower limb amputation should be performed, unless it be the hip-joint that is damaged, when there will generally be so much injury of the pelvic bones and their contained viscera as to preclude the performance of any operation. In the upper limb, if the bones are comminuted, but the soft parts not too extensively injured, excision may be substituted for amputation, especially in the shoulder or elbow-joint. This operation is usually a somewhat irregular proceeding, consisting rather in picking out the shattered fragments of bones, and sawing off projecting and sharp-pointed fragments, than in methodical excision. In children recovery without operation may often be obtained in cases that would be hopeless in the adult.

Separation of an Epiphysis, with Protrusion of the End of the Shaft through the Skin, is occasionally met with in young people, and may be mistaken for a fracture implicating the joint, but in these cases, although the fracture is in close vicinity to the joint, the articulation is not affected, and careful examination will always prove its sound condition. Reduction is difficult, and it is sometimes impossible to maintain it without sawing off the projecting end of the shaft. This is easily done, and union takes place readily between the epiphysis and the remainder of the shaft. In two instances in which I have had to do this in lads—in one near the shoulder, in the other near the ankle—an excellent result without impairment of the joint followed the operation.

4. When one of the **larger Arteries of the Limb has been wounded** by the violence that occasions the fracture, or has been lacerated by the broken bone itself, there may be copious arterial hæmorrhage externally, as well as extravasation into the general areolar tissue of the limb. In such cases, whilst the patient is being examined, and preparation made for operation, dangerous loss of blood must be prevented by the application of a tourniquet. For want of this simple precaution, I have seen very large and even fatal quantities of blood gradually lost, by being allowed slowly to trickle from the wound.

The treatment of this complication will depend upon the amount of hæmorrhage and the size of the vessel wounded. If the vessel be small and the bleeding slight, elevation of the limb and the application of cold may be

tried. If these fail, or if the hæmorrhage be more copious, the Surgeon should freely enlarge the wound and endeavour to expose the artery at the bleeding point, and apply a ligature to the vessel above and below the seat of injury. Owing to the displacement of the parts and the infiltration of the tissues with blood, it may be impossible to find the injured vessel. Under these circumstances the search should not be prolonged to such an extent as materially to increase the disorganisation of the limb, but amputation should be performed.

Secondary hæmorrhage occurring in the course of treatment of a compound fracture of the lower extremity is very rare; if slight, it may be arrested by elevation and pressure. Should these simple measures fail, the Surgeon must be guided by the condition of the wound. If this be favourable it should be enlarged, and an attempt made to ligature the vessel at the bleeding point. If this should not succeed, or if the septic condition of the wound render the attempt impossible, the main artery of the limb should be tied at a higher level. Thus in many cases ligature of the superficial femoral has been successfully adopted in cases of secondary hæmorrhage complicating a compound fracture of the leg. Amputation should be delayed until after the consecutive employment and failure of other methods. Pearce Gould has recorded a case of compound fracture of the leg, complicated by secondary hæmorrhage from the anterior tibial artery on the 25th day, in which he successfully ligatured both ends of the vessel through a free incision.

5. **Comminution or Splintering of the Broken Bone** is always a serious complication, but if drainage can be established and decomposition prevented, it is robbed of most of its dangers. Should the wound become septic, extensive suppuration will set in; the splinters, if completely or nearly detached, will lose their vitality, and not only produce much irritation, but, if numerous, will, on their removal or separation, leave the member shortened and permanently deformed. The treatment of such cases will depend on the seat of the injury and the extent of the comminution. Compound and comminuted fractures of the femur may, except when occurring in the upper third, generally be looked upon as cases for immediate amputation (see p. 358); the only other exceptions being when the comminution is trifling, the splinters large and lying in the axis of the bone, and the subject young. In the arm, forearm, and hand, and in the leg, provided the knee and ankle-joints be not involved, much may be done in the way of removing splinters of detached bone, and sawing off smoothly the rugged ends of the main fragments. The larger attached and "secondary" pieces should be left, as they will throw out callus, and become buttresses of support to the broken bone (see p. 355). If a considerable quantity of splintered bone have been extracted from a limb, care must be taken that in putting up the fracture too complete extension is not maintained, lest a gap be left, which cannot be filled up by new bone, and a weakened limb result. It is better to place the bones in proper apposition, and to let the patient recover with a shortened but strong and otherwise useful limb.

6. In the case of a **bad Compound Fracture requiring Amputation low down in a Limb, with a Simple Fracture high up,** should the amputation be performed above the compound and below the simple fracture, or above both? The answer to this must depend on the condition of the limb between the fractures. Suppose that there be a badly comminuted and com-

pound fracture of the lower third of the leg, with a simple fracture of the middle of the thigh ; or a crush of the hand or forearm, with simple fracture of the middle of the humerus. The proper course to adopt, if the intermediate soft parts are sufficiently sound, is to remove the limb just above the lower fracture, the upper fracture being treated on ordinary principles. But if there be extensive bruising of the limb with deep extravasation between the fractures, then it would clearly be useless to amputate low down, as not only would the stump have to be formed of severely injured tissues, but if septic inflammation set in at the seat of operation, it would speedily spread upwards to the higher fracture, converting it into a compound one of the worst kind. In such cases, therefore, the proper course is to remove the limb at or above the line of the higher fracture.

7. The complication of a **Dislocation high up, with a compound Fracture low down**, is not so serious. The dislocation having been reduced, the fracture is to be treated according to the principles already laid down. If amputation be required it may be safely performed, as in a case under my care some years since, in which I had occasion to amputate the forearm of a young man for a bad crush by machinery, the case being complicated by a dislocation of the humerus.

In some cases in which there is great doubt as to the possibility of saving the limb, especially in compound fractures of the upper limb and foot, the injured part may be dressed antiseptically, and amputation, if necessary, performed at a later period. The exclusion of putrefaction will prevent the septic fever, the spreading inflammation, and the dangers of general infection, which in former times made it safer to perform a primary amputation in all cases in which the prospects of recovery without operation were very doubtful.

Treatment of Compound Fracture.—In the management of a compound fracture, more especially of the lower extremity, special apparatus, such as M'Intyre's, Thomas's, or bracketsplints, swing-boxes, and fracture-beds, are often necessary, in order to obtain access to the wound, and to place the limb in the best position for union. In many cases the starched or plaster bandage may very advantageously be used ; but it requires caution, as swelling and consequent strangulation of the limb may take place under it.

There are several points that require special attention. These are : 1, the Reduction and the Management of Protruding Bone ; 2, the Management of Splinters ; 3, the Treatment of Oozing of Blood ; 4, the Treatment of the Wound.

1. The **Reduction of compound fractures** must be accomplished with the same care and gentleness as that of simple ones. In the majority of cases, no great difficulty is experienced ; and after reduction, the limb should be placed on a well-padded splint, properly protected in the neighbourhood of the wound with oiled silk, so as to prevent soiling of the pads by blood and discharge. In some cases, however, considerable difficulty arises in the reduction, from the protrusion of one of the broken fragments which has been driven through the skin at the time of the accident, or from careless handling of the limb in carrying the patient, or else from the muscular contractions dragging the lower fragment forcibly upwards, and thus causing perforation of the integument. The protruded bone, after being carefully cleaned with some antiseptic solution, must, if possible, be gently replaced, by relaxing the muscles of the limb. Sometimes, however, it is so tightly embraced by the

skin, that enlargement of the wound becomes necessary before it can be replaced. In other cases, again, reduction cannot be effected or maintained, unless the sharp and projecting point of bone be sawn off. The limb as I have found in several cases in which it has been necessary to have recourse to this procedure, is not ultimately weakened, or necessarily shortened by it.

2. In the **Management of Splinters** the Surgeon will be guided by the circumstances. If the splinter be completely loose and small it is always better removed. If it be very large, two inches or more in length, forming in fact rather a fragment of the bone than a splinter, it may be left, even when completely loose. If a splinter is still attached by periosteum it may usually be safely left, even when small.

3. **Treatment of Oozing of Blood.**—In cases in which there is evidently no important vessel wounded, blood often continues to ooze slowly from the wound, and it becomes a question whether anything should be done to arrest it. The only means at our command are elevation of the limb, cold, and pressure. The two former of these may be resorted to whenever the oozing may seem sufficient to render it necessary, but pressure should be avoided if possible. The blood is coming in all probability from the deep parts, very often from the bone itself; pressure, therefore, cannot be applied to the bleeding surface. If applied externally it merely causes the intermuscular spaces and the cavity of the wound to be distended with blood, and should decomposition follow the consequences are most serious. The oozing will always stop by itself after a few hours, and if the patient should lose a few ounces of blood in that way it is better than having the same quantity extravasated into the limb.

4. **Treatment of the Wound.**—After reduction the great object is, if possible, to obtain union of the external wound by the first intention or by healing under a scab, thus converting the compound into a simple fracture and avoiding the danger of suppuration. If the wound be small, clean-cut, and occasioned by the protrusion of the fragment rather than by the direct violence which occasioned the fracture, we may hope to succeed in our object. In order to do this the wound must on no account be washed with simple water, which would materially increase the risk of decomposition taking place in the extravasated blood or serum. If an efficient antiseptic solution be at hand, such as carbolic lotion (1 in 20), perchloride of mercury (1 in 1000), or tincture of iodine (ʒij. to Oj), the wound and the surrounding skin should be cleaned with this and allowed to dry. If no such means are at hand, the blood should be wiped away with a clean dry linen rag. The opening may then be closed in a way recommended by Astley Cooper, by applying to it a piece of lint soaked in the blood and allowing it to dry. A better plan is to seal the wound with lint soaked in collodion or styptic colloid, or in compound tincture of benzoin. In this way an artificial scab may be formed beneath which union may take place. The dressing should be left undisturbed until it loosens of itself, at the end of a week or two, when the wound will probably be found to be closed. If, however, the patient after a few days begins to complain of pain, if the temperature rises and the leg becomes red, hot and swollen, the crust must at once be removed; and if pus flows from beneath it, it is safer at once to enlarge the wound freely.

Supposing the case to be one in which from the size of the wound, or the amount of swelling, it is evidently impossible to hope to close the wound by

scabbing, the Surgeon must then be guided by the same principles as in the treatment of any other open wound. The objects in view are, 1. To clean the wound thoroughly; 2. To provide good drainage; 3. To prevent decomposition of the discharges and infection of the wound; and 4. To maintain perfect rest.

It is better in all cases, whatever mode of dressing it is intended to adopt, to *syringe the wound out with some antiseptic solution*, as by this means any dirt which may have been forced into the wound at the time of the accident, or have adhered to the bone if it have been protruded, may be washed out. The best solutions for the purpose are carbolic acid and water (1 to 20); solution of perchloride of mercury (1 in 1000); tincture of iodine and water (1 to 80); or chloride of zinc (20 grs. to an ounce). The skin round the wound must also be cleaned with the same solution. In syringing out the wound, a glass syringe with a piece of stiff india-rubber tubing on the nozzle should be used. This will penetrate all parts of the wound and yet is not rigid enough to force its way amongst sound tissues. The lotion must be allowed to flow out freely, so as to avoid injecting the surrounding lymph-spaces with the irritating or poisonous antiseptic. In many compound fractures the air gets sucked in by the movements of the limb, and can be felt crepitating in the subcutaneous tissue for some distance on each side of the wound. In these cases it is not necessary to force the solution as far as the air has gone, as the latter seems to deposit its dust close to the wound, where it can easily be reached by the disinfectant. If the wound is many hours old or very dirty, it is well to put into it some iodoform in crystal to ensure a more permanent disinfecting action. Having cleaned the wound thoroughly, *provision must be made for efficient drainage*. In many cases the wound is large enough to allow of perfect drainage; if not, it may be enlarged, but it is scarcely ever justifiable, however large the wound may be, to insert stitches. If the skin is much undermined, a counter-opening may often be made with advantage, and a drainage-tube inserted. The *prevention of decomposition of the discharges and infection of the wound* is carried out by one of the methods of dressing already described in the Chapter on Wounds. In most cases the Surgeon will adopt that method of antiseptic dressing which he commonly uses for wounds in general. The mere fact that the wound is connected with a broken bone does not necessitate any special mode of treatment. The carbolic gauze dressing gave excellent results, but for reasons already given it has been largely replaced by the sal-alembroth and double cyanide gauzes, which possess the great advantage in the treatment of compound fractures that the first dressing can often be left undisturbed for many days or even weeks. For the same reason the dry absorbent dressings, such as iodoform-wool, salicylic wool, sublimate wood-wool, etc. give excellent results. In applying the dressing the gauze or wool should be wrapped smoothly round the limb in sheets so arranged that the dressing can be opened when it requires changing, while the limb is lying well supported and in a comfortable position. Thus in the case of a fracture of the leg treated by Cline's lateral splints, the edge of the dressing should be under the internal splint, so that it can be opened without disturbing the fracture while the leg lies on the outer splint. The dressings must be held in position by the splints; no bandage must be put on under the splints, as it is impossible to do this without disturbing the ends of the bone. In some cases the abundance of the serous discharge

renders it necessary to change the dressing at the end of twenty-four hours. Often, however, the first dressing can be left undisturbed for two weeks or more, when the wound will be found to have healed as if under a scab. If no discharge have soaked through the dressing, and if there be freedom from pain, no excessive elevation of temperature and no impairment of the circulation through the extremity of the limb, the Surgeon will be wise to leave the dressing quite undisturbed. Frequent dressing may undo much of the good done by the prevention of decomposition; for the greatest care cannot prevent some damage to the superficial blood clot and the growing granulation tissue.

The splints applied to a compound fracture should, as far as possible, be so arranged that the dressing can be changed without removing them. With this object the method suggested by Paul of Liverpool will be found most useful. Strips of soft iron covered with india-rubber are bent so as accurately to fit the contour of the limb. These are fixed to the limb by a paraffin or plaster of Paris bandage interrupted at the position of the wound, the edges being sealed with a mixture of bee's-wax and carbolic oil to prevent discharge from getting between the splint and the skin. The wound and the skin around it are thus exposed for the application of the antiseptic dressing. Splints made of perforated zinc may in the same way be purified and enclosed in the dressing. Packing the limb in a fracture-box with sawdust impregnated with perchloride of mercury is a cheap and efficient mode of treatment recommended by Thomas.

The open treatment, the iodoform treatment, and the application of terebene and oil, or carbolic oil, will also give good results if carefully carried out. The dressings may be changed with little or no disturbance to the limb, and thus good rest is maintained, but the prevention of putrefaction is not so certain as in the methods mentioned above.

If decomposition be prevented by one of the above means, and good drainage and rest be maintained, suppuration will be prevented entirely or reduced to an insignificant amount in the great majority of cases, and recovery will take place with but little more constitutional disturbance than in a simple fracture. Union is, however, in many cases delayed for a week or two beyond the time which is sufficient for the cure of a simple fracture even in cases that do well in other respects.

COMPLICATIONS OF COMPOUND FRACTURES.—**Septic Inflammation and Suppuration.**—This may arise from failure of the antiseptic means employed, or the Surgeon may be so placed that he has not the necessary materials at hand with which to undertake efficient antiseptic treatment. Under these circumstances the progress of the case will depend very much upon the nature of the injury. If the wound be of insufficient size to afford good drainage the intermuscular planes may become widely infiltrated with blood and inflammatory exudation; and as decomposition spreads in this, diffuse suppuration, with great swelling, pain and tension will be set up, accompanied by severe constitutional disturbance, possibly ending speedily in fatal septic poisoning, or at a later period in pyæmia. If the wound be larger, allowing free exit to the extravasated blood and the subsequent inflammatory exudation, the suppuration may remain limited to the wound, and be accompanied by but slight swelling of the limb or constitutional disturbance. It is, I believe, in consequence of the free vent thus afforded to the discharges that some of the

worst-looking cases of compound fracture, especially of the leg, eventually do the best.

Should septic inflammation and suppuration occur, an endeavour must be made to *moderate the inflammation* and *lessen the constitutional disturbance.* This is best effected by fixing the limb on a splint in such a way that, although the wound can be dressed, the apparatus shall be left undisturbed as long as possible. The great art in the treatment of a compound fracture under these circumstances consists in not disturbing the limb ; for days or even weeks it may sometimes advantageously be left without interference when once it has been carefully put up. Should diffused swelling take place, the wound become sloughy, and much inflammation be set up in the limb, this may be moderated by the application of warm antiseptic applications, the best being boric acid lint moistened in warm boric lotion. The part should be elevated and but lightly covered, the bed-clothes being well raised by means of a cradle so as not to press on the limb ; care being taken, at the same time, that the bandages be applied loosely, with only a sufficient degree of force to retain the limb upon the splint, as inflammatory infiltration, which might rapidly induce strangulation of the part, is apt to ensue. The constitutional irritation must be subdued by the administration of opiates, together with an aperient, repeated from time to time during the first few days. A moderate and cooling regimen must be employed, and the patient must be disturbed as little as possible. In many cases, if he be addicted to drink, symptoms of nervous irritation soon come on : in these circumstances, it is of great moment that support, and even stimulants, be freely given ; they must be allowed from the very first, and increased in proportion to the depression of the patient's strength.

If there be much bruising and extravasation of blood, great tension of the limb, followed by sloughing, will take place in the neighbourhood of the wound ; free incisions are then required to remove the tension, and, by letting out the decomposing blood and pus, to lessen the risk of gangrene, and diminish the fever resulting from the absorption of the products of putrefaction. If this be not done, deep infiltration takes place through the areolar planes of the limb, and the most extensive local mischief may result, pyæmia being almost certain to ensue. As soon as suppuration is fairly established, fomentations of boric lint, wet salicylic wool, or thick moist oakum dressing should be applied, and the wound may be sprinkled with iodoform ; the burrowing of matter must be prevented by making counter-openings where necessary, and by attention to the position of the limb. The wound must be frequently syringed with carbolic acid lotion, Condy's fluid, or some other antiseptic. The fracture-apparatus must be kept scrupulously clean ; the bandages changed as often as soiled, and the pads well protected with oiled silk. During this period various complications, such as septicæmia, pyæmia, erysipelas, inflammation of the lymphatics and veins, and septic pneumonia, are apt to occur, requiring special consideration and treatment ; so also, if the discharge be abundant, symptoms of hectic may come on, requiring the free use of stimulants and the administration of the mineral acids and other remedies, according to circumstances. As the confinement to bed is necessarily very prolonged in these cases, often extending through many weeks and months, the state of the patient's back should be attended to, and he should early be placed upon a water-cushion or bed, lest sores supervene. As the wound

gradually heals, it may be dressed with some stimulating lotion such as the "red" or "blue" wash.

Septic Osteomyelitis was formerly a very common complication of compound fractures, but since the introduction of antiseptic dressing it is very rarely met with. The pathology, symptoms and treatment of this condition are described in the Chapter on Inflammation of Bone and its Effects (Vol. II, Chap. XLVI.).

Necrosis of the Ends of the Fragments.—In compound fracture in which suppuration has occurred the bone will often be observed lying white and bare, bathed in pus, at the bottom of the wound. But even in this apparently unfavourable condition it may recover, granulations gradually springing up on its surface and covering it in; in other cases, necrosis takes place, and perfect consolidation does not occur until the dead bone has separated. Curling has shown that those portions of necrosed bone which are connected with the lower fragment are slower in detaching themselves. In some instances a large quantity of provisional callus is formed, in which the necrosed bone is embedded, openings remaining through the shell thus formed for the exit of pus. In such cases it may be necessary to cut away some of the new bone to extract the necrosed portions when they are loose; but not uncommonly amputation becomes necessary, from the powers of the patient being unable to carry him through so prolonged a struggle.

The **time required for the consolidation** of a compound fracture in which suppuration has taken place varies greatly, according to the amount of injury done to the bones and soft parts, and the age and constitution of the patient. In the most favourable circumstances, it requires double or treble the time that is necessary for the union of a simple fracture. As soon as some union has taken place, the limb should be firmly put up in gutta-percha or leather splints, with a starched or plaster bandage, so as to enable the patient to be taken out of bed, to change the air of his room, and thus to keep up his general health. In fitting these splints, care must be taken to make an aperture opposite the wound, through which it may be dressed (Fig. 163).

Secondary Amputation may become necessary from the occurrence of traumatic gangrene, and then it must be done in accordance with the principles already laid down when speaking of that operation; it is also occasionally performed in the hope of preventing pyæmia when diffused septic osteomyelitis has set in; but more frequently it is required from failure of the powers of the patient in consequence of septic fever, induced by absorption of the products of putrefaction from the wound and the infiltrated parts around, or by hectic resulting from chronic suppuration. In these circumstances, by removing the source of the mischief in time and seizing an interval when the fever is at its lowest point, the patient's life will in all probability be preserved; the results of secondary amputation for compound fracture in these conditions being by no means unfavourable. Indeed it is remarkable how speedily the constitutional symptoms subside after the removal of the source from which the absorption of septic matter is taking place; the patient often sleeping well and taking his food with appetite the day after the operation.

The proper period to choose for the performance of secondary amputation in the earlier stages of the injury is often a most critical point. As a rule it may

be stated that, if the limb be not removed during the first twenty-four hours, eight or ten days must be allowed to elapse before the operation is done; as during that time the patient is suffering acutely from the early septic fever, and operations during this stage are notoriously fatal. But when granulations begin to spring up in the wound and oppose a barrier to the further absorption of septic matter, the fever subsides, and the limb may be removed with the best prospect of success. The thermometer is the great guide; as soon as it has decidedly fallen from the high septic fever point of from 104° F. to 105° F. to about 100° F. or lower, the operation may be safely undertaken. Should it appear, however, that the patient is becoming rapidly exhausted and will hardly survive to the desired time, amputation may be performed as a last chance during the period of septic fever. In these circumstances, however, the operation is seldom successful; the stump becomes sloughy, diffuse inflammation comes on, septicæmia or pyæmia may set in, and the patient speedily dies. In other cases, after the first fall of the temperature, it may frequently rise again owing to the formation of abscesses in the neighbourhood of the necrosed bone, or the burrowing of pus amongst the muscles; or the patient may gradually be worn out by the profuse discharge. In these cases the patient's power must not be allowed to sink to the lowest ebb before amputation is performed, as then the shock may destroy life; or, if he survive, the immediate effect of the operation in his weakened state predisposes him to be attacked by the various infective processes to which wounds are liable. Much as "conservative" surgery is to be admired and cultivated, and hasty or unnecessary operation to be deprecated, I cannot but think that the life of the patient is occasionally jeopardized, and even lost, by disinclination on the part of the Surgeon to operate sufficiently early in cases of compound fracture, and by too prolonged attempts to save the injured limb.

The success of the operation will in a great measure depend upon the *after-treatment*. Large quantities of stimulants and support are often required in London practice to prevent the patient from sinking. I have frequently given with the best results, eight or ten ounces of brandy, twelve or sixteen of port wine, or two or three pints of porter, in the twenty-four hours after these operations, with beef-tea, arrow-root, or meat, if the patient would take it; and have found it absolutely necessary to do so to obviate death from exhaustion.

At a later period, when, some weeks or months having elapsed, the fracture has not united, the bones are necrosing, and the patient is being worn out by hectic, amputation must be performed at any convenient moment, and is often done with great success if it be not deferred till too late; for here the cause of the mischief is entirely local, and the constitution, suffering only from the debility resulting from it, quickly rallies when it is removed.

Malposition after Fracture.—It may happen that at the end of two or three weeks a fractured bone is found in a faulty position. At this period the bond of union is soft and yielding, and the displacement, if angular, may usually be remedied by frequent re-adjustment of the apparatus, avoiding as far as possible the direct pressure of pads and bandages on the bone itself. If this period be allowed to pass by, and the fracture be allowed to become consolidated, it may be found to be so *badly set* that it is necessary forcibly to bend or break the callus, in order to improve the condition of the limb. When the displacement is angular, and the consolidation not very firm, as is usually

the case, this may be done readily enough ; but if the displacement be longitudinal, and much time have elapsed since the occurrence of the injury, it will be difficult, if not impossible, to remove the deformity. The bending or breaking of the callus is best done under chloroform ; the fracture being then put up again, speedy and perfect consolidation will ensue. In this way I have several times remedied a faulty position in fractured bones, although from six to ten weeks had elapsed from the occurrence of the injury.

Should the consolidation of the fracture be too firm to admit of this, *subcutaneous osteotomy* by Adams's narrow-bladed saw may be employed in some cases with advantage. I have thus divided the fibula into a badly-set Pott's fracture, where the bone had united at an angle pointing inwards, and thus throwing the outer edge of the foot upwards. In other cases again, it may be necessary to expose the bone at the seat of fracture by an incision, and to straighten it by simple division with a saw or chisel, or by the removal of a wedge.

A bone which does not appear to have been very skilfully set, and which presents a certain amount of deformity when the splints are removed, may gradually regain its proper shape. This it does by the muscles of the limb moulding the callus, whilst still somewhat soft and yielding, into a proper shape. The callus may be quite strong enough to bear the weight and to maintain the length of the limb in its full integrity after the removal of all apparatus, and yet be sufficiently yielding to become slowly and gradually shaped by the action of the muscles of the limb when they are left untrammelled by bandages.

But it more commonly happens that a limb which, when taken out of the splints at the proper period, appears to be straight and of good length, gradually yields under the weight of the body and the strain of the muscles ; so that, at the end of a few weeks, most unsightly deformity occurs. In these cases the Surgeon is often unduly blamed ; and to his unskilfulness is attributed that displacement which, in reality, is due to the faulty character of the callus. It must be remembered that there is every degree of firmness of the callus, from that which is of normal consistence to that which is quite unable to support the weight of the limb or body and which yields more or less quickly under the pressure to which it is subjected.

Delayed Union.—Occasionally, more particularly in cases of fracture of the femur, tibia, and humerus, the union between the fragments is *delayed* several weeks beyond the usual period. This arises, in the majority of cases, from constitutional debility rather than from local causes. Several cases of delayed union have been recorded in which repair readily took place after the administration of mercury ; indeed, in syphilitic subjects the constitutional taint should always be treated. A not unfrequent cause of delayed union is "meddling" with the fracture, changing the apparatus, removing splints or frequently testing the solidity. When it is found at the expiration of six or eight weeks after the occurrence of simple fracture that the callus is still yielding, the general health should be improved by tonics, change of air, &c., and the limb securely put up in starched or plaster of Paris bandages. Indeed, I believe that delayed union is much less likely to occur in patients who have from the first been treated by the starched bandage, and allowed to move about, than in those who have been confined to bed or rather to the house in the ordinary way. Dumreicher recommends in these cases to constrict the limb for a short time above the fracture to such an extent as to

cause œdema and exudation round the broken ends. Swelling below is prevented by a flannel bandage reaching nearly to the seat of fracture.

UNUNITED FRACTURE.—A fracture is usually said to be ununited when the broken ends of the bone are not joined together solidly by new bone. There are three varieties of this condition :—1, *Independent Repair of the Fragments,* in which there is no union of any kind; 2, *Fibrous Union,* in which the fragments are bound together by firm fibrous tissue; and, 3, *False Joint or Pseudarthrosis,* in which there is no union between the fractured surfaces, but a capsule of fibrous tissue forms round them resembling the ligaments of a joint.

When the fragments undergo **Independent Repair,** the ends are rounded and the medullary canal closed by a thin plate of bone covered by a newly formed periosteum. In some cases after a time the ends become atrophied and somewhat pointed. This form of ununited fracture may be due to the wide separation of the fragments, as after great loss of bone in a compound fracture or the interposition of soft parts between the broken ends, or from various causes no callus may form; or the early formation of callus may have taken place, but owing to some peculiar general or local condition it may have become absorbed.

In **Fibrous Union** the ends of the bones are united by fibrous tissue, most commonly dense and ligamentous, but sometimes loose in structure. In this condition the early soft callus has formed, but instead of undergoing the normal development into bone it has been converted into fibrous tissue. This is usually the result of insufficient rest during treatment or of faulty position of the fragments. It is the most common form of ununited fracture.

In **False Joint** or **Pseudarthrosis** the two fragments are bound together by dense ligamentous tissue passing from one to the other, forming a more or less perfect capsule around the broken ends (Fig. 167). Between the actual surfaces of the fracture there is no union. They are smoothly rounded, the medullary canal being closed by a thin plate of new bone and invested with a layer of dense fibrous tissue or fibro-cartilage. The two surfaces are more or less adapted to each other like those of a normal articulation. In the humerus or femur one end is usually concave and the other convex; the false articulation thus resembles a normal ball-and-socket joint. In the forearm and leg, as lateral movement is prevented by the presence of two bones, the false articulation more closely resembles a hinge-joint. The inner surface of the capsule may be smooth, as if lined with a synovial membrane, and the cavity may be moistened with a glairy fluid resembling synovia. False joints of this kind are met with only in fractures of considerable standing, and it is probable that they are always preceded by fibrous union, and that the false joint is gradually developed by atrophy of the fibrous tissue between the ends of the bone, and more perfect development of that surrounding them. In very old false joints changes resembling arthritis of normal joints are

Fig. 167.—False Joint in Humerus.

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Fig. 167.—False Joint in Humerus.

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occasionally met with. The surfaces in contact become hardened and eburnated, bony outgrowths may form around the ends of the fragments, and pedunculated fibrous outgrowths have been found attached to the inner surface of the capsule.

All forms of non-union of fracture are undoubtedly rare. I have very seldom met with it in my own practice. The cases that have been under my care have almost all been sent up from various parts of the country. We probably exaggerate the frequency of non-union, if we say that it occurs in the proportion of one in a thousand cases of fracture of the limbs.

Causes.—The causes of ununited fracture are *constitutional* and *local*.

Constitutional Causes.—The constitutional causes that, independently of local conditions, lead to non-union of a fractured bone, are often very obscure, and in many cases none can be detected. Mere debility, independently of some definite constitutional disease, will not lead to want of union. In fact, in weakly children, fractures will unite with great readiness, or if union be delayed for a short time it will, on the improvement of the health, readily take place. The debility induced by the *acute specific diseases* seems in a few recorded cases to have been a cause of non-union, and an attack of *acute pneumonia* has had the same effect. *Syphilis* does not seem to influence the progress of a fracture during the primary and secondary stages of the disease, and it is probable that when it is a cause of non-union the bone was affected before it was broken. *Scurvy* always has an injurious influence on fractures, causing delay in union, if not complete want of repair, and the older writers assert that in severe cases fractures repaired many years before may become disunited. There is no evidence that *cancer* has any influence in delaying union, if the fracture be not actually due to a secondary growth in the bone. In *spontaneous fractures*, from whatever cause, union seldom takes place readily, and often fails altogether.

Pregnancy is said to have a tendency to interfere with the proper union of a fracture; this, however, I consider doubtful, as I have seen a considerable number of cases of fracture in pregnant women, which united in the ordinary time. Billroth and Bruns have made similar observations.

Age.—Failure of union in fractures is very rare in children, and when it occurs in them is seldom remediable, unless it be the result of neglect or of improper mechanical treatment. It is more common at the earlier adult and middle ages. Advanced age appears to exercise no adverse influence on the repair of fractures. I have on two occasions, in my own practice, known very firm consolidation of a fracture of the shaft of the femur to take place in women of ninety years of age.

The **Local Causes** are various and important. *Some bones are much more liable than others* to non-union of fractures. The patella seldom unites by bone in transverse fracture, and fibrous union is common in the lower jaw. Bruns has collected 1274 cases of ununited fracture of the long bones of the limbs with the following results :—409 occurred in the leg, 376 in the arm, 337 in the thigh, and 152 in the forearm. Relatively non-union is most common in the humerus and femur, as the following statistics prove. Of all recent fractures 15·5 per cent. occur in the humerus, but 29·5 per cent. of all ununited fractures are met with in that bone; the femur yields 15·2 per cent. of all fractures, and 26·4 of ununited fractures; the bones of the leg yield 32·1 per cent. of all fractures, and 32·1 per cent. of ununited frac-

tures; the forearm 39·1 per cent. of all fractures, and only 11·9 per cent. of ununited.

Of 72 cases of ununited fracture of the long bones of children collected by D'Arcy Power, 6 occurred in the clavicle, 7 in the humerus, 2 in the fore-arm, 12 in the femur, and 45 in the leg; whilst statistics of fractures in children shew that of 1070 cases 227 were in the clavicle, 228 in the humerus, 328 in the forearm, 213 in the femur, and 74 in the leg.

The *nature of the fracture* has an important influence. About two-thirds of all cases follow compound fractures. In these fibrous union is the most common form, true false joint being rarely formed except in cases of simple fracture.

Want of proper apposition of the fragments may be a cause of non-union, especially when they are so situated that instead of the broken surfaces being in contact, flexion or rotation of one fragment has caused the periosteal aspects to touch. *Wide separation of the fragments*, such as occurs in some cases of fracture of the patella, is another cause, and in compound fractures loss of a large portion of the bone, either directly by the accident or subsequently by necrosis, is often followed by non-union.

The *interposition of soft parts between the fragments* may prevent union. Of this I saw an interesting instance some years ago, in which want of union in a fractured femur was due to perforation of the vastus muscle by the upper fragment, and its entanglement between the broken ends. In transverse fracture of the patella, the torn aponeurosis from the vasti that covers the bone may hang down between the broken surfaces, and thus interfere with bony union.

Extreme comminution is rarely a cause of want of union in simple fractures, but many cases have been recorded in which failure of union has occurred in the lower of two fractures occurring in the same bone at distant points or in the same limb in different bones.

Interference with the vascular supply of one or both fragments is probably not an uncommon cause. For proper union to take place, it is necessary that the callus be formed from both sides of the fracture. If one fragment be so situated that sufficient blood is not sent to it for this purpose, not only want of union, but necrosis, may occur. This is exemplified in fractures of the superior articular ends of the humerus and femur. In intracapsular fracture of the anatomical neck of the humerus, the globular head, being detached from all its vascular connections, may necrose. In intracapsular fracture of the neck of the femur, the head of the bone, still retaining some vascular connection through the medium of the ligamentum teres, has sufficient blood furnished to it to prevent its death, but not enough to form callus—hence fibrous union takes place. Guéretin collected some statistics which seem to show that non-union is more common in fractures occurring in that portion of the bone from which the nutrient artery is directed. Thus in the humerus, in which the artery is directed downwards towards the elbow, ununited fracture is more common above the nutrient foramen than below, and this he attributed to a less perfect vascular supply of the upper part of the bone. A far more probable explanation of this fact is that fractures below the middle of the bone are more easily kept at perfect rest than those above.

The interference with the vascular supply by the *application of a bandage* directly and too tightly to the limb is another possible cause of imperfect repair.

Injuries to nerves seem to have but little effect on union, perfect repair of fractures commonly taking place in paralyzed limbs. Experimental investigations on animals have shown that division of the nerves leading to the injured limb does not interfere with the union of a fracture.

Imperfect rest during treatment is no doubt a very common and important cause of ununited fracture. The best evidence of this is the fact that a very large proportion of all ununited fractures met with in hospital practice are in patients who have been treated on board ship or in remote parts of the country where it has been impossible to procure proper attention or skilled treatment. In cases of compound fracture the disturbance during the dressings may be a cause of non-union.

In a large number of cases, however, the most careful investigation on the part of the Surgeon will fail to discover the cause of the failure of union.

In the **Treatment of Ununited Fracture** the *constitutional* measures are of the first importance. If callus have not been formed, or if, after formation, it have been absorbed under the influence of a cachectic state of the system, the improvement of the patient's health, at the same time that the fracture is put up again firmly so that the ends of the bone are brought into close apposition, may bring about perfect union. In some instances of ununited fracture or delayed union in syphilitic subjects, union speedily takes place after the administration of mercury or iodide of potassium, according to the stage of the constitutional affection. I had under my care a man with ununited fracture of the femur from absorption of the callus four months after the occurrence of the injury, under the influence of incipient phthisis and debility induced by want of food; perfect consolidation was brought about by giving him cod-liver oil and good diet, with rest in bed and a starched bandage to the limb. If there be no very evident cause for the want of union, it will occasionally suffice to put up the fracture firmly in leather or gutta-percha splints, or in a starched or plaster of Paris bandage, and then to allow the patient to move about upon crutches, so that his general health may not suffer, at the same time that a tonic plan of treatment is followed. I have seen several cases in which the want of union appeared to have resulted from too long confinement of the patient to his bed, and the consequent impairment of his health, consolidation taking place when a sounder hygienic system was enforced. This simple plan can, however, be useful only if a short time—at most some months—has elapsed since the occurrence of the injury. In some cases, the empirical administration of mercury is attended with success. In a case of ununited fracture of the humerus, fifteen weeks after the occurrence of the injury, under Liston, union was obtained within a month by putting up the limb in splints, and salivating the patient. When the want of union arises from malignant disease, nothing can be done.

Together with appropriate constitutional treatment, suitable *local means* must be employed to secure steady coaptation of the fragments. In the upper extremity, this may usually be done by means of splints of an ordinary kind. In the leg, the starched or plaster of Paris bandage will be found especially serviceable. Before putting up the limb in the plaster or starched bandage, it is a good plan *to rub the end of the bones forcibly* together, the patient, if necessary, being under the influence of an anæsthetic. In this way a certain degree of inflammation may be set up, which may be followed by a fresh formation of callus.

In the case of ununited fracture of the thigh special apparatus will be required to secure complete fixity. For this purpose the limb should be put in an apparatus, consisting of an outer and an inner iron rod having hinge-joints opposite the hip and ankle, and attached above to a strong pelvic band, and below to the sole of the boot. The thigh part should be provided with well-padded splints, which may be screwed down in opposite directions against the two fragments, so as to hold them firmly in contact. This instrument should be worn for several months; by means of it Smith, of Philadelphia, has succeeded in curing ten out of fourteen ununited fractures in the lower extremity. One great recommendation is, that this plan of treatment is entirely devoid of danger, and enables the patient to take exercise whilst under treatment. In cases with much shortening of the limb and over-riding of the fragments, which are especially apt to occur in the thigh, it will be necessary to employ extension of the limb as well as compression of the fragments against one another. This extension may be made by the lateral iron rods of the above-described apparatus being constructed so as to slide, by means of a rack-and-pinion or screw-mechanism, by which the limb may be gradually lengthened to any required extent (Fig. 168).

Fig. 168.—Apparatus for Ununited Fracture of Femur.

When the failure of union has become very chronic, or a false joint has been formed, it will be necessary to employ operative procedure before union can be obtained. All operations that are undertaken in these cases are conducted on one of two principles: either, 1, *to excite a localised traumatic inflammation in the false joint* and the neighbouring tissues leading to exudation, which, as in the process of union of a recent fracture, may be followed by the development of callus; or else, 2, *by removing the false joint altogether*, to convert the case into a recent compound fracture, and to treat it as such. It can easily be understood that these operative procedures are too serious to be lightly undertaken, or to be had recourse to until other measures have failed.

1. Among the first set of operations,—those that have in view the **Excitation of Inflammation,**—the simplest procedure consists in the **introduction of acupuncture needles,** or in the **subcutaneous section** of the ligamentous band with a tenotome. In this way I have known union effected in a patient of Liston's who had a false joint in the shaft of the femur; though not until after the fracture had been converted into a compound one, and much danger and suffering gone through. Four years afterwards the patient was readmitted into the Hospital, under my care, with fracture of the same bone two inches lower down; on this occasion, union took place in the usual time.

Percussion of the ends of the bone has been employed in these cases by H. O. Thomas. The method consists in protecting the skin with a piece of felt, and then percussing the seat of fracture forcibly with a copper mallet. The percussion may be continued under anæsthesia for several—as many as ten—minutes; it may be required only once, or may need several

repetitions. The effect is a good deal of local swelling and irritation. The limb should be put up as for recent fracture, and a cure may be expected in from four to six weeks.

The **Subcutaneous injection of irritating fluids** has been practised in a considerable number of cases with a fair measure of success. Tincture of iodine has been most frequently used, about 13 to 30 minims being injected between the broken ends if possible. Bruns has collected 11 cases of this treatment, 7 of which were successful. It seems to be quite free from danger.

Dieffenbach proposed to excite the requisite degree of irritation by **driving, with a mallet, three or four conical ivory pegs** into holes bored by means of a drill into the ends of the fractured bone, which are exposed for this purpose. The holes may be bored with the Archimedean drill (Fig. 169), but a common bradawl will do just as well. The soft parts are then to be laid down, and after a few weeks the pegs, which have loosened in consequence of the absorption of the surrounding bone, and also partly of the pegs themselves, should be taken out. It is not necessary to attempt to pin together the ends of the broken bone, but merely to introduce the pegs into

Fig. 169.—Archimedean Drill for perforating Bone.

the extremities of both fragments near to the seat of fracture. I have practised this operation with success in several instances of ununited fracture of the humerus. Bruns has collected 130 cases of this operation, of which 71 were successful, 55 failed, amputation was performed in 1, and 3 died. The operation was most successful in the leg, two-thirds of the cases being cured, while in the arm almost exactly half failed. In the femur, 10 out of 19 were cured, 6 failed, 1 was amputated, and 2 died.

2. The operation of *Removing the False Joint* is the last expedient when simpler means have failed. This was formerly extremely dangerous, and cannot now be regarded as anything but serious, especially when the femur is the bone to be operated on. By the proper use of antiseptics, however, and good drainage and rest, the operation may be robbed of most of its dangers. Bruns has collected 440 cases, the results of which were as follows:—Arm 187, cured 98, improved 3, failed 78, died 5, unknown 8; forearm 65, cured 42, improved 1, failed 17, died 1, unknown 4; thigh 98, cured 50, improved 2, failed 25, died 19, unknown 2; leg 90, cured 47, failed 36, died 4, unknown 3. Probably a large number of the deaths were from causes which we now regard as preventible. The operation is thus performed: The false joint is freely exposed by an incision so placed as to do the least possible injury to the surrounding soft parts. The periosteum is then carefully raised by means of a periosteal elevator from the part it is intended to remove. To facilitate the

perfect exposure of the ends of the fragments, the fibrous tissue forming the false joint may be cut through if necessary. The end of one of the fragments being thoroughly cleaned, it must be sawn off either obliquely or transversely, according to the line of the fracture, or, if more convenient, a chisel and mallet may be used to cut it through. As a rule, a smooth and more regular surface is obtained by using the saw. The opposite fragment is then treated in the same way. The two ends are next brought in contact and wired or pegged together. In wiring the fragments a hole must be drilled obliquely from the surface of each into the medullary canal. A strong piece of thick, tolerably soft, silver wire must be passed through the holes, and the fragments drawn into accurate apposition. The wire may be quite safely left in the wound, and the two ends cut short and hammered down flat on the bone, so as to leave no projecting points.

In all cases some shortening of the limb must necessarily result, but if solid union can be obtained, this is of little consequence. In operating on the forearm or leg, if both bones are affected, care must be taken to remove an equal length from each. If the fracture be very oblique, the section of the bone must be in the same line so as to cause as little shortening as possible.

Nussbaum, in a case of gunshot fracture of the ulna with loss of substance, cut away the rounded ends of the fragments and the fibrous tissue uniting them, and transplanted into the space thus formed a slice of the compact tissue of the upper fragment with the periosteum covering it, leaving a bridge of that membrane undivided. Good bony union resulted.

Operations for ununited fracture rarely succeed when the disunion is owing to other than local causes. They may, however, succeed in old people. I have united a femur that had been disunited for nearly twelve months in a man between sixty and seventy by Dieffenbach's method. The more thickly the bone is covered by the soft parts, the more likely will an operation be to succeed. Hence, the humerus and femur are more favourable for operation than the tibia.

On reviewing the various methods that have been recommended for the treatment of ununited fracture, it would appear that if the period of normal union has been exceeded by but a few weeks, rubbing the ends of the bones forcibly together, constriction, or percussion may be tried, followed by the application of a plaster of Paris bandage. Should these measures have no effect, further efforts may be made to excite a sufficient degree of inflammation by injection of iodine or by subcutaneous section and scraping of the ends of the fragments. Should this fail, the seat of fracture should be cut down upon, and if it be found that there is firm fibrous union, the insertion of Dieffenbach's pegs might be sufficient, as if the proper amount of irritation be set up, the intervening fibrous tissue becomes converted into bone; but if there is a distinct false joint, it had better be removed and the bevelled ends wired or pegged together. If union should fail, much may be done to relieve the patient by properly devised apparatus, but if the false joint be situated in the femur or tibia, the limb may be so useless and cumbersome to him, that amputation may be required as a last resource.

CHAPTER XXI.

SPECIAL FRACTURES.

In considering the special fractures, we shall confine our attention to those of the Bones of the Face, Trunk, and Extremities. Injuries of the Bones of the Head and Spine derive their principal importance from their complication with lesion of the contained organs; hence the consideration of these will be deferred to special Chapters.

FRACTURES OF THE BONES OF THE FACE.

Nasal Bones.—These are usually fractured near their lower ends by direct violence (Fig. 170). There may be no displacement, but more commonly the

Fig. 170.—Fracture of Nasal Bones.

Fig. 171. Spring-Clip for straightening the Nose.

lower fragments are depressed, the bridge of the nose being beaten in. The fracture is nearly always compound, from wound of the mucous membrane. The swelling and ecchymosis that usually attend this injury often render its detection difficult, and interfere with efficient treatment. The depressed bone should be raised with the narrow end of a director by which, guided by the finger outside, the fragment may be forced into proper position. To do this thoroughly it is often necessary to administer an anæsthetic. It may be necessary to insert one blade of a well-padded pair of polypus forceps into the nostril, and seize the depressed fragment between this and the other blade applied externally. Union of the bone takes place very rapidly. It is often moderately firm at the end of a week and solid in two weeks.

The nose without being exactly broken is often twisted to one side, more particularly if the organ be naturally long and pointed. This deformity completely alters the expression of the face, often producing a somewhat ludicrous ... ance. When recent, and more especially when the patient is young, it

may be remedied by the use of a spring-clip (Fig. 171), which presses the distorted end of the nose back to the straight line.

If the **septum** alone be broken, the same treatment must be adopted; the nose being supported and moulded into shape. As a rule, after it has been replaced, the position is maintained: but in some cases, where there is a tendency to sinking of the soft parts of the nose, the introduction of a plug of oiled lint round a piece of catheter, left open for breathing, will be required to retain the organ in proper shape. The hæmorrhage, which is usually rather abundant at first, may be stopped by the application of ice; but occasionally the nostrils require plugging, in order to prevent it from continuing to a dangerous extent. If the **lachrymal bone** be broken together with the nasal, the ductus ad nasum may be obstructed, and the course of the tears diverted. In an injury of this kind, I have seen extensive emphysema of the eyelids and forehead occur on attempting to blow the nose. In some cases, the injury inflicted on the nasal bones extends through the ethmoid to the base of the brain, and may thus occasion death. This I have seen happen from a severe blow on the face with a piece of wood.

MALAR AND UPPER JAW-BONES.—These are seldom broken except by great and direct violence; and their fracture is usually accompanied by external wound, as in gunshot injuries of these parts. More commonly the alveolar processes are detached, and the teeth loosened. The treatment then consists in binding the teeth together with silver wire. In fractures of the *zygoma*, which are very rare, there will be difficulty in mastication from injury to the origin of the masseter, and possibly from fragments, which may require removal, being driven into the temporal muscle.

In some rare cases, **all the bones of the face** appear to have been smashed, and separated from the skull by the infliction of great violence. Thus, South relates the case of a man who was struck on the face by the handle of a crane, and in whom all the bones were separated and loosened, "feeling like beans in a bag." Some years ago I had under my care a patient who had fallen thirty feet over the balusters of a spiral staircase and had struck his face in the fall. He lived about two hours after the accident and on examination the following injuries were found. The lower jaw was fractured through the left ramus, and through the body between the right molar teeth. In the upper jaw a transverse fracture ran completely across from one side of the face to the other, at about the level of the inferior border of the anterior nares. It passed through both superior maxillary bones, the vertical part of the palate bones, the pterygoid processes of the sphenoid on both sides, and the vomer; so that the whole of the alveolar portions of the superior maxilla and the palate formed one piece. This was displaced backwards into the pharynx. The zygoma was fractured on both sides, and a vertical fracture ran on each side from the margin of the orbit through the walls of the antrum; so that on each side there was one large fragment composed of part of the zygoma, the malar bone, and the part of the superior maxillary bone with which it is articulated. The nasal bones, the nasal processes of the superior maxillary bones, the os unguis on each side, and the ethmoid, were smashed into numerous small fragments. There was no fracture visible from the interior of the skull; and no other injuries of importance were found. In another case a woman falling out of a third story window struck her face against the area-railings. The superior maxillæ were broken across trans-

versely above the line of the teeth, so that these and the hard palate could be moved backwards and forwards. She died from a splinter of the roof of the sphenoidal sinus having penetrated the dura mater. I have, however, known several cases of transverse fracture of one superior maxillary bone do well. In such cases the teeth may be tied together with silver wire or the aid of the dentist may be required to fix the displaced fragments by means of vulcanite moulds. The question of feeding the patient is usually one of difficulty, and the food often requires to be introduced by means of a tube.

In **Gunshot Injuries of the Face** there is usually great splintering of the bones. As, however, the vitality of the part is great, necrosis is not likely to ensue; and the partially detached and loosened fragments may be put back into position, and will usually become fixed. There are two principal dangers in these cases: hæmorrhage, either primary or secondary, and abundant fetid muco-puriform discharge. The hæmorrhage, when primary, usually ceases spontaneously, or on the application of cold. If secondary, it may be arrested by cold, by plugging, and by pressure; or, if continuous, and from deep sources, it may possibly require ligature of the external carotid. The fetid discharge from these wounds is a source not only of great discomfort to the patient, but of positive danger, as a cause of septic pneumonia; and, drainage being difficult, he may also suffer from absorption of the septic matter from the raw surface. This risk is best obviated by repeated injections of warm antiseptic solutions, of which the solution of permanganate of potash or boric acid is the best. Whenever it is possible to reach the raw surface in any way, it must, after it has been well washed, be dusted over with iodoform. This exerts a far more powerful and lasting antiseptic influence than any lotion.

LOWER JAW.—This bone is frequently broken, owing to its prominent situation; though its arched shape and great strength enable it to resist all but extreme degrees of violence. All fractures of this bone which implicate the alveolar border are necessarily compound, the laceration of the gum causing them to communicate with the external air. In other cases an external wound, as in gunshot fractures, may communicate with the fracture. Not unfrequently they are comminuted.

Fracture of the lower jaw may occur in various situations. I have seen it most frequently in the **body of the bone**, between the lateral incisor and the canine teeth. The **symphysis** itself is not so commonly fractured, the bone being thick in this situation. The **angle** is more frequently broken. The **coronoid process** can suffer fracture only from the most severe and direct external injury, as from a bullet-wound. The **neck of the condyle** is occasionally broken across.

Fractures near the symphysis are usually vertical, but pass through the bone in a direction from within forwards and outwards, so that the posterior fragment tends to overlap the anterior. Those near the angle are commonly oblique from before backwards, so that a long spiculum of the outer table is connected with the upper fragment.

These fractures are sometimes double: either symmetrically, or, more frequently, one on the side near the symphysis, and the other near the angle.

The **Signs** of fracture of the lower jaw are obvious. The abnormal mobility of the fragments, the crepitus, the irregularity of the line of the teeth and of the arch of the jaw, laceration of the gums, bleeding and dribbling of saliva, indicate the nature of the injury. The displacement and

mobility of the fragments are greater the nearer the fracture is to the symphysis. If the bone happen to be broken on both sides of this line, the middle fragment is much dragged out of place by the depressor muscles attached to it; indeed, in all double fractures, the displacement is very great. In fracture about the angle and lower part of the ramus, the deformity is not so great, owing to the muscles that coat and protect each side of the bone in this situation preventing the fragments from being displaced. When the neck of the condyle is broken through, that process is often much displaced by the action

Fig. 172.—Fracture of Lower Jaw.

Fig. 173.—Four-tailed Bandage applied to Fracture of Lower Jaw.

of the external pterygoid; there is great pain at the seat of fracture and the chin may be drawn to the same side.

When the fracture is near the symphysis, the dental canal escapes; but when it is further back in the body of the bone, and especially near the angle, the canal must necessarily be implicated. It is remarkable, however, that the inferior dental nerve escapes injury or division in many cases altogether, in others for several days, until, perhaps, owing to great displacement or to some effort in reduction, it may be torn across. When this happens, the soft parts of the lower lip, supplied by the mental branch of the inferior dental, are necessarily for a time deprived of sensation, but they soon recover. I have never known any permanent mischief from this cause, nor from the hæmorrhage following laceration of the inferior dental artery.

Fig. 174.—Gutta-Percha Splint: Original Shape.

Fig. 175.—Gutta-Percha Splint, moulded to Shape of Jaw.

The **Treatment** is simple in principle, but often not easy of accomplishment. It consists in maintaining the parts in apposition for four or five weeks, during which time mastication must be forbidden—the patient living

on fluid nourishment—and talking being prohibited. In a simple case in which good position is easily maintained the *four-tailed bandage*, applied as shown in Fig. 173, often answers admirably. Pick suggests that by carrying the upper ends of the bandage behind the occiput, rather than to the nape of the neck as usually recommended, the tendency to displacement of the anterior fragment backwards is avoided. In some cases a *gutta-percha splint* (Fig. 174), moulded to the part (Fig. 175) is of service. It should be lined with lint, and applied with a four-tailed bandage.

Fig. 176.—Hammond's Splint for Fractured Jaw.

The teeth in these cases require special attention. Any that are loosened must be left in, as they will soon contract adhesions, and fix themselves firmly; if necessary, they may be tied to the sound teeth with silver wire, or dentist's silk. Care must be taken that any tooth that may have dropped between the fragments be removed; in one case in which a tooth was overlooked in this position, no union of the fracture took place till it had been removed.

In any case of fracture of the body of the lower jaw, in which a sufficient number of firm teeth are present, *Hammond's splint* (Fig. 176) gives excellent results, and has largely replaced other methods. A stout piece of tinned iron wire is made accurately to surround the whole of the teeth of the lower jaw, and its ends are soldered together. The wire may be conveniently moulded to a cast of the teeth, which can easily be prepared with wax and plaster of Paris. This stout iron wire frame is firmly fixed in position by fine binding wire, which passes separately around individual teeth and binds the splint to them. No support should be taken from the teeth immediately adjoining the fracture, as these are likely to be loosened.

Fig. 177. Fig. 178.
Thomas's first method of Uniting Fracture of the Lower Jaw. A, B, wires passed through drill-holes and coiled by the key, Fig. 178.

When depression, especially near the symphysis, is considerable, Lonsdale's *clamp apparatus*, which fixes the chin and line of teeth, answers the purpose of steadying the fragments extremely well. When the fracture is double, one fissure occurring near the symphysis, the other near the angle, there is often

very considerable difficulty in bringing the fragments into anything like good position, without the aid of some special apparatus. In such cases a cast should be taken of the teeth in gutta-percha, while the fragments are held in accurate position, and from this a metal plate should be modelled, fitted to the teeth, and attached to Lonsdale's clamp or to a stem, and fixed to a horseshoe-shaped splint placed under the jaw, so as to keep the whole steady and solid.

Some cases in which there is unusual difficulty in maintaining apposition, especially if the fracture be double, may be treated by *wiring* the fragments, as advocated by H. O. Thomas.

Fig. 179.—Thomas's second mode of uniting Fracture of the Lower Jaw by Twisted and Coiled Wire.

Fig. 180.—Form of the Coil of Wire.

The bone is drilled on each side of the fracture, and the fragments fixed by means of thick pliant silver wire. Thomas found that the ordinary cross-twist did not hold; he therefore coiled the wire at each side (Figs. 177, 179). In order to facilitate this operation, he devised a set of instruments, comprising a tubular needle to return the wire, and a key for coiling it (Fig. 178). Union generally takes place perfectly in fractures of the jaw, though it is somewhat slow at first, and the fragments continue mobile for some weeks.

The cure is often delayed by the separation of necrosed fragments. If there should be any offensive discharge the patient must wash out his mouth with Condy's fluid and water, after which iodoform must be sprinkled on the wound.

In **Fractures of the Body of the Lower Jaw by Gunshot Injury** there is great comminution and splintering of the bone, followed by copious fetid discharge, which necessitates the free use of disinfectants, and especially of iodoform. In extreme cases the wound may be enlarged and the splinters removed, but no formal excision of any part of the bone should be undertaken.

Fracture of the Hyoid Bone is of rare occurrence; and, though usually the result of direct violence, as a forcible grasp, it has been known to occur from muscular action. The fracture most commonly occurs at the junction of the body and great cornu. The fragments form a sharp salient angle: there is much pain and irritation, increased by speaking and deglutition. There is salivation from interference with the movements of the tongue and cough; and considerable difficulty in breathing may be present. *Reduction* is accomplished by pressing the fragments into position, either externally or by passing the finger into the mouth. Should one piece of the bone be driven much in, it may possibly require to be drawn forwards with a tenaculum. The neck should then be fixed with a stiff pasteboard collar to prevent displacement.

FRACTURES OF THE UPPER EXTREMITY.

Fractures of the upper extremity may occur from direct or from indirect violence. When from *direct* violence any portion of any bone from the tips of the fingers to the trunk may be broken. But indirect violence is the more common cause; and the seat of the fracture depends on the way in which the violence is directed.

The CLAVICLE is more frequently broken than any other bone in the body, except the radius. For this there are three reasons. First, it is exposed to the influence of direct violence; secondly, it receives all shocks transmitted through the shoulder in a horizontal direction to the trunk; and, thirdly, being the only direct osseous support of the upper extremity, it receives by transmission through the scapula every shock that is communicated to the hand when the arm is extended. Notwithstanding its exposed position, it is comparatively seldom broken by direct injury. The great majority of the fractures occur from indirect violence, such as falls on the shoulder and on the hand. This bone would be more frequently broken than it is, were it not that it resembles two segments of a circle looking in opposite directions, so as to form an S-shape which admirably enables it to withstand indirect violence. The clavicle is occasionally fractured by muscular action—more particularly from the swing of the arm, as in a back-handed blow. When the accident occurs from this cause, it is usually about the middle of the bone, and on the right side. Compound fracture of the clavicle can occur only from bullet-wounds, or some similar severe and direct injury inflicted upon the bone.

Fractures from direct violence are usually transverse, and often comminuted; from indirect violence they are oblique. The latter are attended with much greater deformity than the former. Fractures of this bone in infants and young children are usually transverse; sometimes the bone is merely bent, or is fractured on one side only. The injury is usually occasioned by falling out of bed. Such accidents are frequently overlooked by careless nurses; but the child's crying whenever the arm is moved directs attention to the part, and the Surgeon then finds some deformity, with a node-like swelling about the middle of the bone.

Both clavicles are occasionally, though rarely, fractured. In one such case, which was under my care, the patient, a young man of 20, had twelve ribs broken as well, in a railway accident, notwithstanding which he made an excellent recovery.

Complications.—In simple oblique fracture of the clavicle, there is rarely any serious complication. But when the fracture is the result of direct violence, the same force that breaks the bone may injure subjacent parts of importance. The subclavian vein may be compressed or wounded, or the brachial plexus of nerves may be compressed or torn; the first rib may be broken by the crushing violence, and the pleura wounded. In a case recorded by Bowlby partial rupture of the subclavian artery occurred (p. 407).

The clavicle may be fractured at any point between its acromial and sternal ends. 1. Most frequently the **Great Convexity** is broken; the bone bending here when pressed upon from its extremity, the curve becoming increased, and at last giving way. This fracture may arise from direct violence, but usually is the result of falls on the hand or shoulder. 2. It may be fractured

nearer the acromion between the two **Coraco-clavicular Ligaments.** 3. Its **Outer End** may be broken off externally to the outermost point of insertion of the trapezoid ligament, between it and the acromion. These latter two fractures can scarcely occur from indirect, but are almost always the result of direct, violence. 4. The clavicle may be broken internally, that is, to the **Sternal Side of the Rhomboid Ligament,** usually about three-quarters of an inch from its sternal articulation. This injury is of very rare occurrence. R. W. Smith, although admitting its possibility, states that there is no actual proof, from dissection, of its having occurred. According to J. Hutchinson, Junr., there are but three cases on record of separation of the epiphysis of the clavicle. The epiphysis joins the shaft about the 25th year.

The **Signs** will depend upon the seat of fracture. When the bone is broken *between the conoid and trapezoid ligaments*, there is little, if any, displacement, but pain on pressure, some crepitus on moving the shoulder, and slight irregularity on running the finger along the bone are usually present. When the fracture is *external to the coraco-clavicular ligaments*, there is a remarkable displacement of the scapular fragment, which is turned forwards and inwards, with a slight inclination downwards, nearly at right angles to the rest of the bone, apparently by the dragging of the weight of the shoulder, the point of which is rounded forwards (Fig. 181). When the fracture occurs *about the middle of the bone*, or at any part on the *sternal side of the scapular ligaments*, there is a well-marked deformity, owing to a triple displacement of the inner end of the outer fragment inwards, downwards, and slightly backwards, while the outer end is rotated forwards (Fig. 182). This displacement is due to two causes, one of which is mechanical and the other muscular. The displacement downwards is due chiefly to the weight of the arm, but the contraction of the deltoid would also aid in depressing the inner end of the outer fragment. The displacement inwards is due to the action of the muscles passing from the chest to the arm and scapula, the pectoralis major and minor, and the latissimus dorsi ; the rotation forwards and the pointing of the sternal end of the outer fragment backwards is due to the more powerful action of the pectoral muscles. The outer extremity of the inner fragment appears to be elevated, the skin being drawn tensely over it ; but this is owing rather to the depression of the outer portion of the bone ; it is usually kept fixed by the antagonism between the sterno-cleido-mastoid and great pectoral muscles. It may, however, in some cases be raised. This is when the clavicular portion of the sterno-cleido-mastoid muscle is unusually strong, and when the fracture has taken place just outside its insertion into the clavicle ; or it may be raised and pushed forwards, by the inner end of the outer fragment getting below or behind it. On looking at a patient with fracture of the clavicle in this situation, the nature of the injury is at once evident. The approximation of the point of the shoulder towards the sternum ; the prominence formed by the outer end of the inner fragment, over which the skin is stretched ; the sudden depression under this, and the crepitus, which can easily be induced by elevating and rotating the shoulder at the same time that the elbow is pressed to the side, indicate the nature of the injury. The attitude of the patient is remarkable ; he sits, leaning his head down to the

Fig. 181.—Fracture of Clavicle, outside of Coraco-clavicular Ligament.

affected side, so as to relax the muscles, and supports his elbow and forearm in the sound hand, in order to take off the weight of the limb; he is unable to raise his arm from the side, and any attempt to do so causes severe pain.

When the fracture occurs near to the sternal end of the bone, it is usually, if not always, transverse. If it occur internally to the rhomboid ligament, the outer fragment is displaced forward, but remains on the same horizontal level as the sternal fragment. If the triple displacement of the outer fragment, characteristic of fractured clavicle, viz., in a direction downwards, forwards, and inwards, have occurred, then R. W. Smith believes that, however near the joint the fracture may appear to be, it must in reality

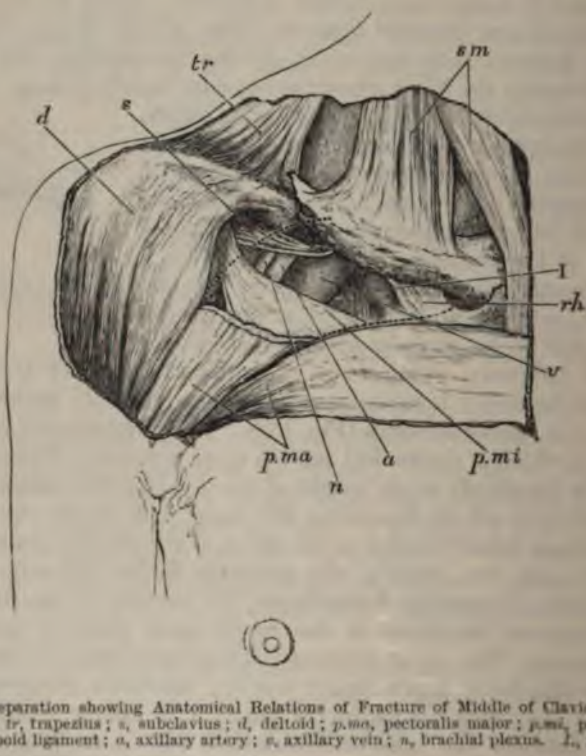

Fig. 182.—Preparation showing Anatomical Relations of Fracture of Middle of Clavicle. *Sm*, sterno-mastoid; *tr*, trapezius; *s*, subclavius; *d*, deltoid; *p.ma*, pectoralis major; *p.mi*, pectoralis minor; *rh*, rhomboid ligament; *a*, axillary artery; *v*, axillary vein; *n*, brachial plexus. *I.*, first rib.

have occurred externally to the costo-clavicular ligament, which is too strong to admit of this displacement, or to be ruptured, and so to allow it to take place.

In ordinary simple fracture of the clavicle the blood-vessels passing under the bone are very rarely, if ever, injured or even compressed. This is owing to the manner in which the outer fragment is displaced, its sternal end being pushed in front of them and to their inner side.

Comminuted Fracture of the Clavicle is the result of severe direct violence. It is a dangerous accident, as the subclavian vein and adjacent plexus of nerves, or the upper part of the pleura, may be seriously injured. In a case that was under my care, the subclavian vein was apparently

wounded, great extravasation of blood taking place about the shoulder and neck, and the circulation through the veins of the arm being so much interfered with as to threaten gangrene. The case, however, did perfectly well under the continuous application of evaporating lotions to the shoulder, and attention to the position of the arm. But in another case, gangrene of the arm took place, leading to amputation at the shoulder joint. The patient died of pyæmia, and a fragment about one inch long separated from the posterior part of the clavicle was found lying upon, and compressing, the subclavian vein. Dr. John Ogle relates a case of comminuted fracture of the clavicle from direct violence, in which the right internal jugular vein was lacerated by one of the fragments, there being great extravasation of blood.

I have known only one instance in which the subclavian artery was injured. The left clavicle was broken by direct violence, a cart-wheel having passed over the shoulder. An aneurism rapidly formed in the subclavian artery, whether however by direct injury or as the result of severe strain was uncertain. C. Heath, under whose care the patient was, amputated at the shoulder-joint.

Compound Fracture of the Clavicle can of course be produced only by direct violence, and in such cases any amount of injury may be done to the underlying and neighbouring parts by the force that breaks the bone or by fragments driven in. The vein, artery, or nerves may be injured, and their liability to injury will, for obvious anatomical reasons, be in the order named.

Treatment of Simple Fracture of the Clavicle.—There are few fractures for the cure of which so great a variety of ingenious and complicated contrivances has been devised as those of the clavicle, and there are few in which so much ingenuity has been displayed in vain ; for, however perfect the apparatus may appear to be, it seldom answers the purpose intended, viz., to cure the fracture without deformity. I believe that more may be done, with a little skill and patience, by simple means than by the most elaborate mechanical contrivances.

When the fracture occurs at the tip of the acromial end of the clavicle, the tendency to rotation of the shoulder forwards may be corrected by fixing the arm to the side with plaster of Paris or strapping in the manner to be described for fractures of the middle of the bone. When the bone is broken between the coraco-clavicular ligaments there is but little displacement and the same treatment will suffice.

But when the fracture is situated towards the middle of the bone, or indeed at any point to the inside of these ligaments, the case is more difficult, and numerous methods of treating it have been invented. The objects aimed at in all are to draw the outer fragment outwards, to force its outer end backwards, and by supporting the weight of the limb to correct the displacement downwards. It is impossible to mention here more than the few methods of treatment that seem most practically useful.

Treatment by Plaster of Paris.—This may be carried out as follows : The patient lies on his back on a flat table, with his head and shoulders projecting, and supported on a narrow board which passes beneath the spine. The shoulders now fall backwards, and by bringing the elbow of the affected limb to the side and usually somewhat forwards, the fragments of the broken clavicle can as a rule be well adjusted. A flannel bandage is now carried around the chest and the affected limb, including the board behind, and over

this a sufficient number of turns of a plaster of Paris bandage securely fixes the limb to the side of the chest. The plaster bandages should be carried circularly around the arm and the chest, and obliquely over the flexed elbow, the forearm and the opposite shoulder. Finally, when all is firm, the board is slipped down from under the bandages. This method, which will be found especially useful when there is unusual difficulty in maintaining the parts in apposition, depends for its success upon the well-known fact that the deformity of a fractured clavicle is often best reduced by placing the patient in bed with a narrow pillow beneath the spine.

Sayre's Treatment by Adhesive Plaster.—Lewis A. Sayre of New York recommends the following mode of treatment, which has been found to act extremely well. Two strips of plaster, spread on strong calico or moleskin, are to be cut, each about three and a half inches wide or less, according to the size of the patient. One of these is to be long enough to encircle the arm, and afterwards to pass one and a half times round the body. A loop in this is first passed round the arm immediately below the axillary

Fig. 183.—Strap drawing back Shoulder.

Fig. 184.—Strap raising Shoulder.

border. The non-adhesive side of the plaster must be towards the skin, and the loop must be secured by stitches. It must be quite loose, so that there shall be no risk of compressing the vessels. When this has been made fast, the elbow must be drawn well *backwards*, and the strip of plaster is carried firmly round the body and its end brought up and secured as in the figure. A few stitches may be inserted to render its hold more secure (Fig. 183). The second strip must be of sufficient length to pass from the sound shoulder, obliquely round the chest beneath the elbow of the injured side, and to overlap for some six or eight inches. A slit must be cut in it for the olecranon. Before applying this the elbow must be raised and at the same time drawn well *forwards and inwards*, when the shoulder will be thrown backwards and outwards, the first strip of plaster acting as a fulcrum. In most instances this will place the fragments in good position, but in each individual case the Surgeon must endeavour to adjust the limb in such a way as best to relieve the deformity, and he may find that this is sometimes most satisfactorily accomplished by keeping the elbow in the mid-axillary line, or even directing it slightly backwards. The position must be maintained by

the application of the second strip of plaster, which passes obliquely from the sound shoulder across the back to beneath the elbow, and thence over the forearm and hand to the sound shoulder again, as in Fig. 184. Finally, a calico bandage is passed alternately round the chest and arm, and obliquely beneath the forearm and over the opposite shoulder.

Treatment by the Pad in the Axilla.—In this method a thick wedge-shaped pad in the axilla is used as a fulcrum to bring the shoulder into the desired position. The method has given good results, but it has one serious drawback, viz., the risk of the production of gangrene by the undue pressure of the pad on the vessels of the limb. This can hardly occur if the Surgeon sees the case frequently and observes the state of the circulation in the fingers. But, unfortunately, patients do not always present themselves when told to do so, and thus three or four days may pass without the case being seen. During this time gangrene may have set in unaccompanied by any pain, the limb being numbed by the pressure on the brachial plexus in the axilla. More than one such case has occurred, and as excellent results can be obtained by other methods without this danger, the treatment by the hard pad in the axilla had better be abandoned.

Treatment by the figure-of-8 Bandage.—This consists in drawing the shoulders forcibly backwards by a bandage passing beneath the arm-pits, over the shoulders, and crossing in the middle line of the back. The arm is then supported in a sling. However carefully the axillæ be padded, the treatment is extremely irksome to the patient and cannot be recommended. A modification of this method, recommended by Syme, and known as the *treatment by the three handkerchiefs*, may sometimes be useful as an immediate application. A large handkerchief, folded diagonally till it is about one inch and a half wide, is placed round each shoulder so that it shall lie in front in the hollow between the coracoid process and the head of the humerus. The two ends are secured by a single turn behind the shoulder, and then twisted together so as to form a single cord. These cords are then knotted firmly together in the middle line, while the shoulders are forcibly pulled backwards; a folded towel must be put along the spine to prevent the knot hurting the patient. The third handkerchief is then put on as a sling firmly supporting the elbow.

In *children*, in whom these fractures often occur, there is frequently a difficulty in keeping the bandages properly applied; in these circumstances the starched apparatus will be found very useful, care being taken to re-apply it as often as it becomes loose, lest deformity result. In young children, especially if the fracture be of the "greenstick" variety, it is often unnecessary to do more than fix the arm to the side and raise the elbow with a flannel bandage. Fractured clavicles occurring in females, to whom any irregularity of union in this situation would be very annoying, are best treated by keeping the patient lying flat on her back in bed, with the arm fixed to the side, for the first two or three weeks. By this plan, which is as old as the days of Hippocrates, I have seen better results produced than by any other.

When *both* clavicles are broken, the patient should be kept in bed, with the arms fixed to the side, or in some cases both limbs may be fixed by means of plaster of Paris applied in the manner already described.

In **Comminuted Fracture of the Clavicle**, it must always be remembered

detached along with it. Mobility of the coracoid would, therefore, be a valuable sign of this rare fracture. The **Treatment** of such an injury, if it were recognised, would consist in keeping the whole arm well raised and fixed to the chest, with a pad in the axilla.

FRACTURES OF THE HUMERUS.—In studying the fractures of the humerus, we must divide that bone into three parts—the Upper Articular End, the Shaft, and the Lower Articular End.

1. **Fractures of the Upper Articular End of the Humerus** not unfrequently occur, constituting an important class of injuries which have been carefully studied by Astley Cooper, and more recently by R. W. Smith.

Five kinds of fracture of the humerus are met with in the immediate vicinity of the shoulder-joint: Fractures of the Anatomical Neck, Simple and Impacted; Fractures of the Surgical Neck—Simple and Impacted; and Separation of the Great Tuberosity.

Fracture of the Anatomical Neck of the Humerus.—The head of the bone is detached from the shaft, a little above or at the line of insertion of the capsule, and thus the fracture may or may not be purely *intracapsular*. This fracture is occasioned by severe falls or blows on the shoulder. A fall on the hand or elbow may dislocate the humerus, or fracture its shaft, but it cannot break its upper articular end.

This injury is very rare, and the signs of it are by no means distinct, though much light has been thrown upon them by the labours of R. W. Smith. There is loss of motion in the shoulder, with some swelling and considerable pain, together with slight deformity; an irregularity, produced by the upper end of the lower fragment, can be felt towards the inner side of the joint; crepitus is easily produced; and there is, on measurement from the acromion to the olecranon, shortening to the extent of about one-third of an inch.

When this fracture is *impacted*, the upper fragment penetrates the lower one. In consequence of this, the axis of the humerus is directed somewhat inwards towards the coracoid process; here also some irregular osseous swelling may be detected. The head of the bone can be felt in the glenoid cavity, but is not in the axis of the limb, the elbow projecting slightly from the side, while there is at the same time a hollow some little distance under the acromion. There is consequently more deformity about the joint in the impacted than in the simple intracapsular fracture, with the same impairment of motion, but crepitus is wanting, or a slight grating may be felt, on firmly grasping the shoulder and rotating the elbow.

In fracture of the anatomical neck of the humerus the portion of bone broken off may be completely loose, like a foreign body in the joint. Under these circumstances, theoretically, it might necrose and give rise to destruction of the articulation, but there is no recorded case of such a complication. In most cases, so far as the evidence of museum specimens goes, the injury is not accurately intracapsular, the line of fracture passing outside the capsule towards the greater tuberosity, the fragment being then attached to the capsule at its upper part. In other cases it is impacted, and new vessels penetrate it from the lower fragment. A case recorded by Boyer shows that when loose it may be gradually absorbed, and there is also evidence that if perfect rest be maintained, the loose fragment may form new adhesions. But even if it remains free there is no reason why it should cause inflammation and suppuration any more than a loose piece of cartilage chipped off the femur

head, so as to touch the crown, owing to some of the fibres of the deltoid having lost their points of attachment; and it may be determined by the existence in a minor degree of some of the preceding signs, which prevent the accident from being confounded with paralysis of the deltoid from contusion; and especially by the tip being felt to be detached. But as has already been stated, this may be a congenital defect, to which perhaps attention has been directed only when the shoulder has been bruised or otherwise injured.

The **Treatment** consists in raising the elbow so as to take off the weight of the limb, and to push up the acromion by the head of the humerus. If the extremity only be broken off in front of the acromio-clavicular articulation, a pad may be placed between the elbow and the side in order to direct the arm somewhat upwards and inwards, and the limb must be fixed in this position by a bandage and sling. Should the fracture have taken place at or behind the line of the clavicular articulation, the treatment must be the same as that for fractured clavicle.

When the base of this process is broken across, there is not much separation between the fragments, and union usually takes place by bone. When the apex is detached, fibroid or ligamentous union generally occurs, the fragments being widely separated.

3. The **Coracoid Process** is but seldom broken, there being not more than ten or twelve unequivocal cases on record. It can rarely happen except by very direct violence. There is in the Museum of University College a recent preparation showing a fracture of the base of this process, implicating the glenoid cavity, and complicated with fracture across the base of the acromion; and another specimen, from a subject in the dissecting-room, showing a fracture through the middle of the process united by a fibrous band three-quarters of an inch in length. In spite of the attachment of such powerful muscles as the pectoralis minor, biceps, and coraco-brachialis, the displacement is not great as the process is kept in position by the coraco-clavicular ligaments. The only **Treatment** that can be adopted is to put the arm in a sling and fix it to the side.

4. **Fracture of the Neck of the Scapula** immediately behind the glenoid cavity is a rare injury. Its existence has been doubted; A. Cooper and South have stated that cases so described are, in reality, fractures of the upper end of the humerus. A case, however, recorded by Spence puts the occasional occurrence of the injury beyond doubt. A man was brought into the Edinburgh Infirmary, who had fallen on his shoulder while intoxicated. There was falling of the limb towards the axilla, with projection of the acromion and flattening of the deltoid; and crepitus was felt. The contour of the shoulder was restored by drawing the arm from the side and raising the limb. The man died some days afterwards from meningitis, the result of an injury to the head received during the fall. On examining the shoulder, "the fracture was found to pass obliquely from below upwards and forwards, commencing about half-an-inch behind the origin of the long head of the triceps, and separating the neck and four-fifths of the lower part of the glenoid cavity from the scapula. The long head of the biceps and the whole of the glenoid ligament had also been torn from the upper fragment of the glenoid cavity, and carried along with the displaced portion." In fracture through the neck of the scapula, the coracoid process would necessarily follow the glenoid cavity, being

detached along with it. Mobility of the coracoid would, therefore, be a valuable sign of this rare fracture. The **Treatment** of such an injury, if it were recognised, would consist in keeping the whole arm well raised and fixed to the chest, with a pad in the axilla.

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in the knee. Croft and Clutton have each recorded a case in which the head of the bone, separated at the anatomical neck, was dislocated into the axilla and subsequently removed by operation.

Fracture of the Surgical Neck of the Humerus.—In this injury, the bone is broken below the tuberosities, but above the insertions of the pectoralis major, latissimus dorsi, teres major, and deltoid muscles. This accident is most frequent in adults, but it may occur in children as well, the separation then taking place through the line of junction between the epiphysis and the shaft of the bone. The upper fragment is slightly abducted by the

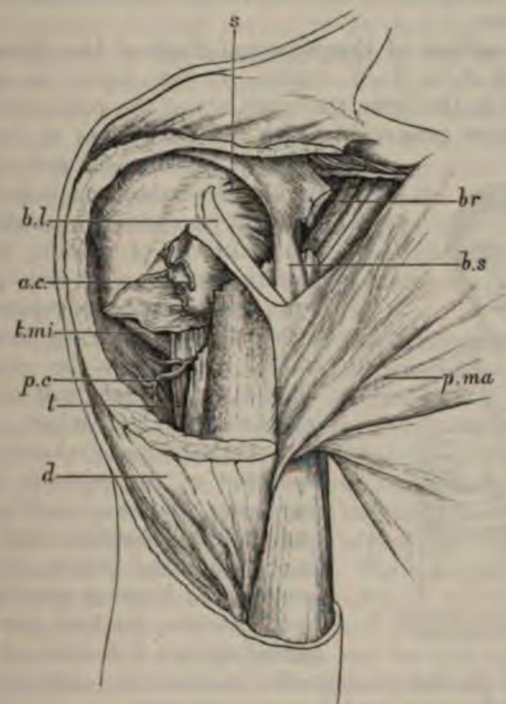

Fig. 185.—Preparation showing Anatomical Relations of Fracture through the Surgical Neck of the Humerus. *s*, subscapularis; *b.l*, long head of biceps; *b.s*, short head of biceps; *t.mi*, teres minor; *t*, triceps; *d*, deltoid; *p.ma*, pectoralis major; *a.c*, anterior circumflex artery; *p.c*, posterior circumflex artery; *br*, brachial plexus.

supraspinatus, but probably undergoes little or no rotation (Fig. 185). The shaft is drawn inwards by the pectoralis major, latissimus dorsi, and teres major, and upwards and forwards into the axilla, and towards the coracoid process, by the biceps, coraco-brachialis, triceps, and deltoid.

The **signs** of this fracture are sufficiently obvious. The glenoid cavity is filled by the head of the bone, which can be felt in it, but cannot be made to move by rotating the shaft. Below this there is a depression causing some flattening of the shoulder, but there is no prominence of the acromion; crepitus is easily produced if extension be made to bring the rough surfaces in contact, and there is great mobility of the lower fragment, with shortening

of the limb to the extent of from three-quarters to one inch; but the most remarkable sign is the prominence formed by the upper end of the shaft of the humerus, which projects under the integuments, and can readily be felt under the coracoid process, when the elbow is pushed upwards and rotated. The axis of the bone also is directed obliquely upwards and inwards towards this point. In consequence of the irritation of the nerves of the brachial plexus by this fragment, which is often very sharp and angular, a good deal of pain is complained of in the arm and fingers. This sign, however, is rarely met with in children, when the epiphysis is separated from the shaft, owing to the greater smoothness of the fractured surfaces. There is often very great extravasation of blood in this fracture, owing to laceration of branches of the circumflex arteries.

Impacted Fracture of the Surgical Neck of the Humerus has been especially treated of by R. W. Smith. In this injury, the upper fragment being penetrated by the lower, the continuity of the bone and its firmness are in a great measure preserved; hence the usual signs of fracture, such as mobility, displacement, and crepitus, are not readily obtainable, and indeed the signs of this injury are chiefly negative. Thus, there is impairment of motion, with slight deformity about the joint and upper part of the arm; and occasionally crepitus is obtainable, with difficulty, by firmly grasping the head of the bone whilst the elbow is rotated. There is, as a rule, slight shortening, amounting to less than half an inch.

Fig. 186.—Apparatus for Fracture of the Neck of the Humerus.

In patients under twenty years of age *separation of the epiphysis* from the shaft may occur, and care must be taken not to confound this accident with a dislocation. In children under puberty dislocation of the head of the humerus scarcely ever occurs. In the fracture, the head can be felt in the glenoid cavity; but above all the broad end of the shaft, for the line of separation is transverse, may be felt drawn up under the coracoid process, and cannot be mistaken.

Treatment of Fractures of the Neck of the Humerus.—If there be much swelling from contusion, evaporating lotions should be applied for a few days. A small pad may then be placed in the axilla, and the arm bandaged to the side whilst the elbow is drawn slightly forwards, so as to throw the upper end of the shaft backwards and outwards towards the head of the humerus. This position of the elbow applies chiefly to fracture of the surgical neck. The hand and wrist only are now supported in a narrow sling, which allows the weight of the arm to counteract the displacement upwards. The whole is then steadied by a carefully-fitted poroplastic shoulder-cap (Fig. 186).

In the management of some of these fractures, I have found a very convenient apparatus in a leather splint about two feet long by six inches broad, bent upon itself in the middle, so that one half of it may be applied lengthwise to the chest, and the other half to the inside of the arm; the angle formed by the bend, which should be somewhat obtuse, is well pressed up into

the axilla, and filled with padding to maintain its shape. In this way the limb is steadied, and the tendency to displacement inwards of the lower fragment is corrected.

The examination and reduction of these fractures must be conducted without violence, lest any impaction of the fragments be disturbed, or portions of untorn capsule be broken through. In some cases, fracture of the neck of the humerus is followed by atrophy of the bone, though good union has taken place. In some cases of separation of the epiphysis the difficulty of reduction is very great, especially if some time has elapsed before the nature of the injury has been recognized. Helferich records a case of this kind in which he succeeded in effecting reduction by exposing the site of the separation and enlarging the slit in the periosteum in which the end of the shaft was engaged.

Compound Fracture of the Surgical Neck of the Humerus is not of common occurrence. I have had a case under my care in which this accident happened to a lad from a fall out of a window. The fracture was transverse, and the upper end of the lower fragment was driven upwards, and protruded through the deltoid, to the extent of an inch and a half. It was reduced, with difficulty; as great irritation was set up around the seat of injury, and as there was a tendency to recurrent protrusion of the upper extremity of the lower fragment, this was turned out by enlarging the wound, and about an inch and a half of it sawn off. Union took place between the fragments, and a cure, with a very useful arm, was effected.

Separation of the Great Tuberosity of the Humerus occurs occasionally from falls and blows upon the shoulder; but more commonly as the result of the violent action of the three muscles inserted into it. In this injury there is a double displacement; the tubercle is carried upwards and somewhat backwards away from the head of the bone, and under and towards the posterior part to the acromion process; the head is drawn upwards and inwards by the muscles passing from the trunk to the arm, as well as by the flexors of the arm, in such a way that it lies upon the inner edge of the glenoid cavity under the coracoid process, and is indeed almost luxated. The consequence of this double displacement is a great increase in the breadth of the shoulder, which is nearly double its natural size; on examination, a rounded tumour—the head of the bone—movable on rotating the arm, can be felt under the coracoid process, whilst another osseous mass—the great tuberosity—may be felt at the outer and back part of the joint; between these a sulcus is perceptible, and above them the acromion is abnormally prominent. Crepitus may be felt by bringing the two portions of bone into apposition and rotating the arm. This accident, which is rare, has been most carefully described by Guthrie and Smith.

The **Treatment** consists in an attempt to bring the detached tuberosity into contact with the head of the bone, and retain it there. This may be done by placing a small pad in the axilla, and bringing the elbow to the side so as to throw out the head of the bone, at the same time that, by means of a compress, the tuberosity is pressed into proper position, the arm being supported in a sling. Another method consists in elevating and extending the arm from the trunk; in carrying this out, it is necessary that the patient be confined to bed, the arm being supported on a pillow.

The **Period of Union in a Fracture of the Neck of the Humerus** is about five weeks, at the end of which time the apparatus may be removed,

injury is apt to be mistaken for dislocation of the forearm backwards, which is also common in young subjects.

Transverse Fracture of the Lower End of the Humerus, just above the condyles, occurs occasionally in adults. The displacement backwards of the forearm and lower fragment, the pain, and crepitus, indicate the nature of the accident.

Fracture of either Condyle of the Humerus may arise from blows and falls on the elbow. There is considerable pain about the seat of the injury, but usually not much displacement; unless, as shown in Fig. 188, there be a transverse fracture of both condyles, constituting what may be termed the T-shaped fracture of the lower epiphysis of the humerus. Crepitus, however, may readily be felt by rotating the radius, if it be the external condyle that is injured; or by flexing and pronating the forearm, if it be the internal condyle that has been detached.

The **Treatment** of all these injuries must be conducted on very similar principles. The swelling, which rapidly supervenes, usually requires the

Fig. 188.—T-shaped Fracture of Lower Epiphysis of Humerus.

Fig. 189.—Angular Splint applied to front of Limb.

application of cold lotions, or of irrigation; the arm being flexed, and supported in an easy position on a proper splint. After the subsidence of the swelling, the fractured bone, whatever be the precise nature of the injury, is best maintained in position by being put in an angular splint applied to the anterior aspect of the limb (Fig. 189); the forearm being kept midway between pronation and supination, and well supported in a sling.

It is in these particular fractures that passive motion should be had recourse to early, some degree of rigidity of the joint being otherwise often left. The motion should be begun in adults at the expiration of a month or five weeks: in children, at the end of three weeks after the occurrence of the accident. Union usually takes place readily. I have, however, seen one instance of an ununited fracture of the external condyle of the humerus in a boy about ten years old.

Period of Union.—These fractures unite quickly, bony union being complete in four weeks, but it is seldom that the patient recovers the use of before the end of the sixth week.

y of Nerves in Fracture of the Humerus.—In simple fracture

of the shaft of the humerus, it may happen that the trunk of the musculo-spiral nerve, where it winds round the bone, may be damaged, either by the fracture itself or by becoming involved in the subsequent formation of callus so as to be paralysed. So also when the fracture is lower down, and the external condyle is broken off, the posterior interosseous branch of that nerve may be injured, whilst very rarely the median and ulnar nerves are damaged. When the musculo-spiral is paralysed, supination is imperfect, and extension of the hand and fingers is entirely lost; the forearm becomes pronated, and the hand and fingers flaccid, so that a form of *wrist-drop* ensues; all the muscles supplied by the musculo-spiral nerve being paralysed. Some degree of supination, however, can be effected by the action of the biceps. Although the extensors of the wrist and fingers have become paralysed, yet, when the fingers are flexed into the palm (Fig. 190 *a*), they can be extended rapidly, and with some degree of force, at the first interphalangeal articulations, as far as is represented in Fig. 190 *b*. This limited movement of extension is due to the action of the interossei and lumbricales which, being supplied by the ulnar and median nerves, do not participate in the paralysis, for, as pointed out by Duchenne of Boulogne, the interossei extend the second and third phalanges and flex the first phalanx, flexion of the two distal phalanges being accomplished entirely by the long flexors.

Fig. 190.—Paralysis of Hand (Wrist-Drop) after Fracture of Humerus.

When the posterior interosseous nerve only is paralysed, the loss of supination and extension is necessarily less complete; these movements being still practicable to a limited extent, through the medium of the long supinator and the long extensor of the wrist, which are supplied from the main trunk. If


Fig. 191.—Permanent Flexure from Paralysis after Fracture of Humerus.


Fig. 192.—Apparatus for Wrist-Drop after Fracture of the Humerus.

the paralysis of the extensors and supinators be allowed to continue for some time, the forearm and hand are drawn into a state of permanent flexion and pronation by secondary shortening of the muscles that act in those directions (Fig. 191).

The treatment of this complication of simple fracture of the humerus must be conducted on the principles laid down in the Chapter on Injuries of Nerves. The patient should be encouraged to use the hand as much as possible as soon as the state of the fracture will allow of it, and a splint may be applied at night to prevent the occurrence of deformity. In order to overcome the

flexion of the hand and fingers, due to the unopposed action of the long flexors, a splint with a handpiece admitting of upward movement may be employed to raise the hand and extend the fingers forcibly (Fig. 192).

In a case of pressure on the musculo-spiral nerve by one of the fragments or by the callus, Ollier of Lyons removed a portion of the callus with a chisel and mallet, so as to expose the nerve, and also excised a portion of bone (apparently of the lower fragment), which was strangulating the nerve. At the end of six and a half months, the patient had regained considerable power of extending his wrist. Many cases of the same kind have since been recorded.

Compound and Comminuted Fractures of the Elbow-Joint are necessarily serious accidents. They are commonly occasioned by falls on the point of the olecranon, which is the process of bone most frequently and extensively fractured. In some cases the olecranon escapes injury, whilst the lower epiphysis of the humerus is splintered into many pieces; and more commonly, perhaps, both bones, the ulna as well as the humerus, are injured. As the integuments over the point of the elbow are thick and hard, very extensive comminution of the bones may occur with very little apparent injury of the soft parts. When these fractures are the result of gunshot injury, the soft parts may be extensively torn, and the bones greatly shattered. In the cases that occur in civil practice, I have seldom seen much laceration of the soft parts.

The **Treatment** of these accidents must depend on the amount of injury done both to bones and soft parts. If the articulation be simply opened with little laceration of the surrounding soft parts, and no comminution of the fractured bone, the limb should be saved. If the bones be much shattered, the soft parts not being seriously implicated, removal of the splinters, or resection of the injured joint, will enable the Surgeon to save the rest of the limb; but if the soft parts be extensively contused and torn, the bones at the same time being comminuted, amputation of the arm may be required. If an attempt be made to save the joint without operation, great attention must be paid to drainage, rest, and prevention of decomposition. If the cavity become filled with septic matter, not only will there be severe septic fever, but abscesses will form in front of and around the joint, the splintered fragments will necrose, and excision, or possibly amputation of the limb, will be necessary in a few weeks. These cases, however, as a rule, do very well when treated antiseptically.

Perfect rest may in these cases be obtained by the plan recommended by H. O. Thomas of slinging the hand up over the upper part of the chest by a bandage secured by a clove hitch to the wrist, and tied round the neck.

If the comminution be such as to render removal of the splintered fragments necessary, or if it be evident that recovery can take place only with a stiff elbow-joint, resection should be performed. In these cases the question may arise whether partial or complete removal of the articulation should be practised. This will depend in great measure upon circumstances. If the comminution be such as to require the removal of a considerable length of the humerus, it is better, if possible, to leave the bones of the forearm untouched, otherwise a flail-like arm is certain to result. If but little length of bone has to be removed, there is some danger of a stiff elbow resulting unless the whole cartilage-covered surfaces of the bones are removed. In cases in which a secondary excision becomes necessary after an attempt to save the joint has

failed, it is better to follow the ordinary rule of removing all the articular surfaces even if only one is injured, as in these cases the cartilages have often necrosed from the irritation of the septic discharges, and would seriously delay the cure. When primary resection is determined on, the sooner the operation is done the better; when a secondary operation is necessary, after septic inflammation has followed the accident, the Surgeon must wait till the septic fever begins to subside, and suppuration is fully established, and then he should do it with as little delay as possible, lest hectic or pyæmia supervene. The operation as performed differs in no material respect from the same operation for disease of the articulation, which will be described in Chapter XLIX. In primary excision great care must be taken to save the periosteum as much as possible, otherwise a flail-like joint may result. In secondary operations, as the periosteum is loosened by the inflammation, it usually is saved without difficulty.

Fig. 193.—Fracture of Olecranon.

FRACTURES OF THE FOREARM.—1. The only fracture of the bones of the forearm that commonly occurs *in the vicinity of the elbow-joint*, is that of the **Olecranon**; this happens most commonly from falls upon the elbow, but it may occur from muscular action. Bardenhauer and König describe fracture of the olecranon by indirect violence from forced over-extension of the elbow in falls on the hand. The displacement is sometimes considerable, the detached fragment being drawn upwards by the triceps muscle. Frequently, however, when the ligamentous expansion from the tendon of this muscle to the fascia of the forearm is not torn through, there is but little separation of the fragments. There is always effusion of blood into the joint, which necessarily prevents the close approximation of the fragments. In the majority of cases, as the injury takes place from direct violence, there is much swelling about the joint; and not unfrequently the fracture is comminuted or compound.

Fig. 194.—Apparatus for Fractured Olecranon.

The **Treatment** is best conducted by moderately straightening the arm, and maintaining it in that position by means of a well-padded light wooden splint laid along its fore part. But, although the arm should be kept nearly straight, it should not be quite extended. The best and most easy position in which to put it up is that into which the arm naturally falls when hanging by the side; in this there will be seen to be slight flexion at the elbow (Fig. 194). If the forearm be too rigidly extended on the arm, it may be carried back-

flexion of the hand and fingers, due to the unopposed action of the long flexors, a splint with a handpiece admitting of upward movement may be employed to raise the hand and extend the fingers forcibly (Fig. 192).

In a case of pressure on the musculo-spiral nerve by one of the fragments or by the callus, Ollier of Lyons removed a portion of the callus with a chisel and mallet, so as to expose the nerve, and also excised a portion of bone (apparently of the lower fragment), which was strangulating the nerve. At the end of six and a half months, the patient had regained considerable power of extending his wrist. Many cases of the same kind have since been recorded.

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wards beyond the straight line, owing to loss of the resistance of the olecranon against the fossa at the back of the humerus. In order to facilitate the approximation of the fragments, Lauenstein recommends puncture of the joint with antiseptic precautions and evacuation of the blood and serum. The fluid could be more safely removed with the aspirator, and the treatment certainly deserves further trial.

As a rule, union takes place by firm fibrous tissue, but bony union has sometimes been obtained. Should the union be so loose as to render the arm useless, it has been recommended to cut down on the seat of fracture, freshen the bony surfaces, and apply a wire suture as in the treatment of ununited fractures elsewhere. In order to do this without the risk of suppuration, the strictest antiseptic precautions must be observed. The operation has been successfully performed by Lister, MacCormac, and others; but the cases in which such an operation could be required are rare.

Period of Union.—A simple fracture of the olecranon is usually united with sufficient firmness to allow of the splint being abandoned in from four to five weeks, after which passive movement must be carefully carried out to get rid of the stiffness of the joint.

In **Compound Fracture of the Olecranon,** the joint must be syringed out with an antiseptic solution, and treated by some form of antiseptic dressing. The fragment should be fixed to the ulna by wire sutures, care being taken to provide drainage from the joint on each side of it. In cases in which suppuration has taken place, and where there is a probability of ankylosis, the semi-flexed would be preferable to the straight position. If destruction of the joint follow, excision may be necessary.

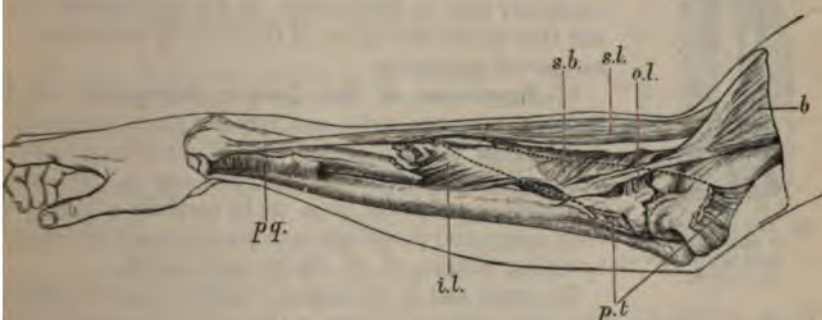
Fracture of the Coronoid Process of the Ulna has been supposed by many Surgeons to be a common complication, and, indeed, a cause of dislocation of the ulna backwards. There is every reason, however, to believe that this is an error, and that, in point of fact, it is one of the rarest accidents—at least, if we judge by the small number of recorded cases or of preserved specimens of this injury. Hamilton states that there are but eight cases on record in which there was reason to believe that this accident had occurred; that in not one of these cases were the symptoms unequivocal; and that in none did dissection afford an opportunity of demonstrating this fracture. There are but four preparations in existence, according to Hamilton, illustrative of this injury, and all these are doubtful. In the cases in which this accident has been supposed to have occurred, the injury has arisen from falls on the palm of the hand, by which the ulna has been driven backwards, and the coronoid process, striking against the lower end of the humerus, splintered off. In a case related by Liston, the injury is said to have been produced by muscular action in a boy, who, hanging for a length of time by his hands from a high wall, fell to the ground, and was supposed to have sustained this fracture. Whether the fracture actually occurred is doubtful; and, if it did, it is still more doubtful whether it was occasioned by the contraction of the brachialis anticus muscle, or by the violence of the fall.

In the present uncertain state of our knowledge, I forbear to speak of the supposed symptoms of this accident. If it were suspected, the proper treatment would consist in placing the limb in angular splints.

2. **Fractures of the Forearm** are very common, and both bones are usually broken. The deformity varies much, but there is often marked angular

formity and some shortening. If one bone only, commonly the ulna, be ictured, more attention will be required in establishing the precise nature of e injury.

In the **Treatment** of fractures at or below the middle of the forearm, the sition midway between pronation and supination should be chosen, as this ves the greatest natural interval between the two bones, and brings the lower gment into a position corresponding to that of the upper (Fig. 195). A ictured forearm is usually put up while the patient is seated, with the arm ised to the level of his head and the elbow bent at a right angle. In this sition the bones are midway between pronation and supination when the umb points towards the face. Plain wooden splints are applied to the lmar and dorsal surfaces of the forearm. They must be equal in breadth the greatest transverse measurement of the limb, so that the bandages may t press on the soft parts between the edges of the splints, and thus ap-



ig. 195.—Preparation showing Anatomical Relations of Fracture of Radius below the Insertion of the Pronator radii teres. *b*, biceps; *s.l*, supinator longus; *s.b*, supinator brevis; *p.q*, pronator quadratus; *p.t*, pronator teres; *i.l*, interosseous ligament; *o.l*, orbicular ligament.

oximate the broken bones. If the bones be put up in an improper position squeezed together, a mass of callus may unite them across the interosseous ace, and thus prevent pronation and supination (Fig. 196). The splints ust be evenly padded, and in applying them care must be taken that they held perfectly parallel.

If the fracture of the radius be situated above the insertion of the pronator dii teres the upper fragment is supinated, and therefore during the treatment e hand must also be kept supinated so that the lower fragment is brought to a corresponding position. With the arm hanging by the side and the bow flexed at a right angle, the palm of the hand will be directed upwards, d this position is best maintained by the application of a palmar splint to e forearm and a dorsal rectangular splint to the arm and forearm.

The splints should always be removed and the limb examined without disrbing the fracture at the end of every second day for the first week, as the essure of the pad between the bones is apt to cause sloughing without any in or other sign of mischief. In such cases the slough may extend to the xor muscles, and the median and ulnar nerves may become paralysed by essure. When the slough separates, the flexor muscles may be exposed and come involved in the scar in healing, thus leading to forced flexion and

stiffness of the wrist and fingers. I have seen more than one case in which this has happened.

Green-stick fracture of the forearm in children is far from uncommon, and the bones should be snapped completely through before the splints are applied, otherwise angular deformity is almost certainly left.

Fig. 196. — Obliteration of the interosseous space in a fracture of the forearm.

In a case of fracture of the upper end of the ulna, under the care of Marcus Beck, there was marked angular deformity backwards, caused by the action of the triceps. This deformity could be reduced only by putting up the limb with the elbow extended.

Period of Union.—The average time of union in the forearm is five weeks.

Compound Fractures of the Forearm seldom give much trouble or require amputation, but they very commonly lead to obliteration of the interosseous space, and thus impair the utility of the limb, by preventing pronation and supination.

3. **Fractures of the Lower Extremity of the Radius,** near the wrist, are very frequent, especially in women after the age of 45. Their importance, not only from a diagnostic point of view, but also in reference to treatment, has caused them to be carefully studied; and their nature and pathology have been specially investigated by Colles, Nélaton, R. W. Smith, and Gordon.

The lower end of the radius is liable to several different kinds of fracture. The most common of these is that which is generally called **"Colles's Fracture,"** after the eminent Surgeon who first fully described it. In this fracture the carpal end of the radius is broken across, usually by a fall on the palm of the hand, the lower fragment being displaced backwards. Gordon, who gave great attention to the mechanism of this fracture, states that, in twenty-seven old specimens examined by him, the line of fracture posteriorly varied from $\frac{3}{8}$ to $1\frac{3}{4}$ inch, and anteriorly from $\frac{3}{8}$ of an inch to two inches above the carpal border of the radius, being in ten one inch and under, in ten more than one inch but not over $1\frac{3}{4}$ inch, in the others indefinable. The fracture is usually oblique from before backwards. Besides Colles's, three other fractures are met with in this situation: 1, Simple Transverse; 2, with comminution of the Lower Fragment; and 3, with firm Impaction of the Upper into the Lower Fragment.

The **Signs** of fracture of the lower end of the radius vary greatly, according to the nature of the injury. In an uncomplicated case, there is usually no very great displacement; but there will be noticed some tumefaction about the wrist, a swelling at its dorsal aspect, loss of the movement of the radius, and crepitus on rotating the bone whilst the hand is drawn down. When the fracture is *comminuted*, and still more so when *impacted*, the deformity is very marked and characteristic; so much so, that it may be looked upon as diagnostic of these forms of this accident. The displacement gives rise to a remarkable undular distortion of the wrist. On looking sideways at the hand and forearm held midway between supination and pronation, it will be seen that there is a considerable dorsal prominence apparently situated just above

the back of the carpus (Fig. 197); immediately underneath this, on the palmar aspect of the wrist, opposite the annular ligament, there is a remarkable hollow, confined to the radial side of the limb; a little above this—that is to say, on the lower part of the anterior aspect of the forearm—there is another rounded prominence, not nearly so large, however, as the one on the dorsal aspect. The hand is abducted and rotated outwards, so that its axis is oblique to that of the forearm; the inner border being somewhat convex, and the styloid process

Fig. 197.—Fracture of Lower End of Radius: Side View.

Fig. 198.—Fracture of Lower End of Radius: Back View.

of the ulna projecting sharply under the skin (Fig. 198). The radial side of the wrist is, on the contrary, somewhat concave and shortened.

The pain is very severe, and is greatly increased by moving the hand, especially by making any attempt at supination. The hand is perfectly useless, the patient being unable to support it. All power of rotation is lost, the patient moving the whole of the arm from the shoulder, and thus apparently, but not really, pronating and supinating it. Crepitus can readily be felt when the fracture is unimpacted or comminuted; but when it is impacted, the most careful examination fails to elicit it. Simultaneous fracture of the radius on both sides of the body is a rare occurrence.

The *Cause of the Deformity* has been the subject of much discussion, owing to the rarity of opportunities of dissecting recent fractures of this kind. Surgeons are now agreed, however, that the dorsal prominence is due to the lower fragment, carrying the carpus with it, being displaced backwards and upwards; whilst that on the palmar aspect is due to the projection forwards of the lower end of the upper fragment, which is thrown into a state of pronation. The pronation of the upper fragment is evidently due to the pronatores quadratus and radii teres; but to what is the displacement of the lower fragment due? Is it to the peculiar manner in which the two fragments are locked into one another? or is it due to muscular action? Some years ago I had an opportunity of dissecting the limb of a woman who died from other causes in University College Hospital twelve days after meeting with this accident. On examining the left arm, which presented all the signs of this injury in a marked degree, and from which Fig. 198 was taken, a transverse fracture of the radius was found about an inch above its articular surface. The lower fragment was split into three portions, between which the upper fragment was firmly impacted to the depth of more than half an inch. The three portions into which the lower fragment was split were of very unequal size; the two

posterior ones being small, consisting merely of scales of bone; the third fragment, the largest, comprising the whole of the articular surface of the radius, which was tilted somewhat upwards and backwards, carrying the hand with it. To this fragment were attached the supinator longus, and part of the pronator quadratus; the ligaments and capsule of the joint were uninjured.

Fig. 199.—Fracture of Lower End of Radius; Displacement of Articular Surface.

This case presented the appearance usually met with in this kind of injury; the lower fragment being displaced in such a way that its articular surface looked slightly backwards, and somewhat outwards, so as to be twisted as it were upon its axis. The upper fragment was found in a state of pronation, and was driven into and firmly impacted in the lower one.

That the deformity in this case was the result of impaction, there could be no doubt; and that this is so in many cases, is proved by an examination of several specimens preserved in the London Museums, and by the difficulty of accounting in any other way for the occasional impossibility of properly reducing these fractures. The great traction that is usually required to remove the deformity, and the absence of distinct crepitus until after forcible traction has been employed, indicate the existence of this impaction.

Mechanism.—The mode in which the accident occurs, and the position of the hand at the moment of its coming into contact with the ground, will, I think, materially influence the kind of fracture as well as the amount and character of the resulting deformity. When a person falls on his hands outstretched to save him, the limb is usually not completely pronated. It is half-way between complete pronation and the mid-state between pronation and supination. Complete pronation is a forcible muscular effort which is not carried to the full extent at the moment of danger. The hand is in fact three-quarters

Fig. 200.—An old Colles's Fracture of the Radius. Showing the dorsal prominence made by the Lower Fragment and the Carpus, and the palmar projection caused by the anterior part of the lower end of the Upper Fragment.

pronated—not wholly so. The effect of this position is, that the ulnar border is directed slightly downwards and first comes into contact with the ground, and the fracturing force is directed in a line that is somewhat towards the radial side, as well as backwards and upwards. Hence the hand is driven from the ulna towards the radius, causing the strongly marked projection of the styloid process of the ulna; and, the radius being broken across at its lower end, the fragment, carrying with it the carpus and hand, is driven backwards, upwards, and slightly outwards, causing the double deformity of a projection

at the back of the forearm immediately above the carpus, and the concavity along the outer line of the radius.

But if, as sometimes happens, the hand be forcibly pronated at the moment when it touches the ground, then the shock, which is received principally on the ball of the thumb and the radial side of the wrist, impinges in a direction obliquely from before backwards, and from without inwards, as well as from below upwards, and thus has a tendency, as soon as the bone is broken, to rotate the lower fragment on its own axis, and to tilt the articular surface somewhat upwards and outwards. As the upper fragment descends, its posterior surface of compact tissue is forced into the cancellous structure of the lower fragment until the two posterior portions of compact tissue come into contact; and thus the upper line of compact tissue is driven into the lower fragment, to an extent corresponding to the degree with which the fragment is rotated upwards and backwards. If the bone be brittle, or the force be continued after this amount of impaction has taken place, the lower fragment will be splintered. The prominence of the styloid process of the ulna in this case is the result of the shortening of the radial side of the wrist and hand, consequent upon the impaction.

Fig. 201.—Fracture of Lower End of Radius: Displacement of Lower Fragment.

Fig. 202.—A section of the bone from which Fig. 201 was taken, showing the impaction of the compact tissue of the posterior aspect of the Upper Fragment into the cancellous tissue of the Lower.

When the fracture is unimpacted, or when it is comminuted without impaction, I agree with R. W. Smith that the displacement of the lower fragment is the result of muscular action alone. This I have had an opportunity of observing in the following case. A man, 64 years of age, fell from a height of twenty-five feet, breaking the left radius just above the wrist, and at the same time receiving such serious injuries of the pelvis and abdomen, that he died in an hour after admission into the Hospital. On dissecting the arm about twenty-four hours after death, I found that the radius was fractured transversely about half an inch above its lower end, and that the lower fragment was completely comminuted. The wrist, which presented all the signs of this fracture in a marked, but not an extreme degree, could not be restored to its normal shape by any amount of traction. On exposing the muscles of the limb, it was found that the supinator longus was attached to the lower, and the pronator quadratus to the upper fragment; the latter muscle being slightly lacerated at its lower part. The upper fragment was strongly pronated. The main obstacle to reduction was found to exist in the two radial extensors of the wrist, the tendons of which were excessively tense; next to these, the special extensors of the thumb presented most tension, and then the supinator longus, which was far less tense than either of the other sets of muscles, but especially than the radial extensors, the tendons of which were strongly defined. On dividing these tendons, and on pressing the lower end of the upper fragment outwards, reduction was easily effected. Here the

displacement was evidently due to two causes. The upper fragment was forcibly pronated by the action of its special pronators; and the hand, with the lower fragment attached, was drawn upwards and backwards by the radial extensors of the wrist. There was no impaction or interlocking of fragments, but perfect mobility, and hence muscular action was enabled to come into play.

In another case which I have since dissected, the muscles chiefly at fault were the radial extensors; next to these the extensors of the thumb; the supinator longus being but slightly if at all contracted.

Besides this injury, R. W. Smith has described a fracture of the lower end of the radius from falls upon the back of the hand, in which the inferior fragment is displaced forwards. In these cases the character of the deformity indicates the nature of the injury. It can readily be reduced by traction.

In another variety of fracture in this situation, the lower end of the radius and that of the ulna are broken off, resembling very closely dislocation of the wrist backwards. But the existence of grating, the ready reduction of the swelling, and the attachment of the styloid processes of the radius and of the ulna to the carpus, with which they move, will be sufficient to establish the diagnosis.

In the **Treatment** of the ordinary fracture of the radius near the wrist, numerous methods are employed by different Surgeons. In all cases the deformity must be reduced, if possible, by extension and counter-extension, and if there be impaction, considerable force may be required to disentangle the fragments and remove the dorsal prominence. Whatever splint be used, prolonged fixation of the wrist and fingers must be avoided.

Carr's splint will be found most efficient in overcoming the deformity, and comfortable to the patient (Fig. 203). It consists of a narrow splint slightly hollowed out to fit the radius, obliquely across the end of which is a cylinder of wood about four inches long by half an inch in diameter. This is thinly padded with folded lint and applied to the forearm in such a way that the cylinder corresponds to the metacarpo-phalangeal articulations. The displacement must be reduced and the hand well drawn towards the ulnar side as the splint is applied. The fingers are now bent down so as to make them firmly grasp the cylinder of wood. A short splint, about two inches wide, is then placed on the back of the forearm, and both are secured by strapping and bandage. The bandage may at first be applied so as to keep the fingers in the flexed position, grasping the cylinder, but after the first week it must not extend beyond the carpo-metacarpal articulation, the fingers being left perfectly free to move. By the use of this apparatus the tendency to stiffness of the fingers is greatly diminished.

Fig. 203.—Carr's Splint.

Pistol-splint.—This consists of a wooden splint of the shape represented in Fig. 204. It should be carefully padded, the padding being made thicker opposite the lower fragment, and then, with the straight portion held verti-

cally, the head of the splint should be fixed to the back of the hand. Gentle extension should then be made, and the hand bent to the ulnar side by raising the straight portion of the splint to the horizontal position, so as to make it lie against the back of the forearm, where it should be held, while another straight splint, extending from the elbow to the lower end of the upper fragment, is placed on the front of the forearm. Both splints should then be fixed by means of a roller, care being taken to have the anterior splint well padded along the radial border, so as to counteract the tendency to pronation of this part of the bone. The arm must then be placed in a sling. The pistol-splint should be worn for a fortnight or three weeks. At the end of this time a gauntlet of gutta-percha, or other plastic material, may be moulded to the wrist and worn instead of the splint. All apparatus should be discontinued at the end of five weeks in the adult, a week or two earlier in children. The fracture unites in the course of a month or five weeks. After the first week it is well, especially in elderly people, to leave the fingers free, and to encourage movement of them, lest that painful stiffness result which is so common a sequela of the accident. Passive motion of the wrist-joint may, however, often be commenced, with great advantage to the patient, before the union of the fracture. If the hand and fingers be kept fixed on the splint until the fracture is fully united, very troublesome and painful stiffness will result. It is frequently fully three months before this is so far diminished, even by the use of friction and douches, as to enable the patient to use the fingers, the stiffness of the wrist being often due to the extension of a fissure into the joint.

Fig. 204.—Pistol-Splint.

Gordon's splint is represented in Fig. 205. The lower end of the dorsal splint, and the process of the palmar splint which fits the ulnar border of the hand, are curved forwards, so as to remedy the backward displacement of the lower fragment. The bevelled portion attached to the palmar splint is intended to fix the upper fragment.

Fig. 205.—Gordon's Splint.

FRACTURES OF THE METACARPUS AND FINGERS are of so simple a character as scarcely to call for detailed remarks. There is only one accident to a metacarpal bone that can lead to any difficulty in diagnosis. This is the case in

which the neck of the bone is broken transversely, so that the head is carried forwards with the finger, and thus simulates closely a dislocation of the fingers towards the palmar surface. A comparison of the line of the bent knuckles, together with crepitus on rotation, will determine the nature of the injury. The *Treatment* of a fracture of the metacarpal bone of the thumb is best carried out by the application of a narrow plaster of Paris bandage as a spica to the thumb and wrist. In the case of the others a leather or gutta-percha gauntlet may often suffice, but in some instances the deformity is best reduced by the use of an anterior wooden splint or by bandaging the fingers over a roller bandage or ball-shaped pad placed in the palm. In compound fracture of these bones, every effort should be made to save the part; if removal become necessary, it should be as limited in extent as possible (p. 100).

Period of Union.—A fracture of one of the bones of the hand is firmly united by the end of the third week, when splints will no longer be required.

FRACTURES OF THE PELVIS AND THE LOWER EXTREMITY.

FRACTURES OF THE PELVIS.—The pelvic bones can be broken only by great and direct violence. The complete circle which they form, their solidity, and the strength of their articulations, enable them to resist all indirect causes of fracture. In civil life these bones are usually broken by crushes of the body, as between a cart and a wall, by falls of rock in mining accidents, or by the crushing force of railway collisions.

When broken, the pelvis usually gives way at the rami of the pubes and ischium in front, and across the ilium, at or near the sacro-iliac synchondrosis behind, usually on the side opposite to that of the fracture in front (Fig. 206). The pubes may be, but rarely is, broken across its body, and the symphysis is seldom torn through. When one side of the pelvis is thus broken away from the rest of the bone, it and the attached lower extremity are necessarily connected with the rest of the body only by the soft parts that unite the pelvis to the spinal column and trunk. These are consequently liable to severe stretching, laceration, and other injury.

In some cases, portions of the crest of the ilium only are detached. In others, the rami in front may be broken without corresponding posterior fracture. Such injuries can, however, arise only from gunshot wounds or similar forms of direct violence. When the fracture results from a crush, double fracture, back and front, must necessarily occur.

The danger in simple fracture of the pelvis arises from the injury to the important soft parts contained within it. Muscles, nerves, and blood-vessels may be stretched or torn. The bladder may be wounded by a spiculum of bone from the pubes or ischium; or the urethra may be torn, perhaps completely across, from the same cause. When the urethra is torn, a slight oozing of blood will usually be observed at its orifice, with possibly much deep ecchymosis of the perinæum.

The nature of the injury is usually apparent from the great degree of direct violence that has been inflicted upon the part; from the pain that the patient experiences in moving or in coughing; from the inability to stand, in consequence of a feeling as if the body were falling to pieces; and from the ready mobility of the part and crepitus on seizing the brim of the pelvis on each side and moving it to and fro, or on rotating the thigh of the affected

side. Blood effused into the iliac fossa may extend forwards and produce discoloration along the line of Poupart's ligament. In examining a patient with suspected fracture of the pelvis, care should, however, be taken not to push the investigation too closely, lest injury be inflicted by the movement of the fragments. In those cases, indeed, in which the fracture does not extend completely across the pelvis, or in which it is seated in the deeper parts of the ischium, an exact diagnosis may be very difficult, and should not be attempted.

Treatment.—As the great danger in fracture of the pelvis consists in the possibility of the urethra having been torn or the bladder wounded, the first thing to be done is to pass a gum catheter. If the urine be clear, it may be concluded that the urinary apparatus has not been injured, and the catheter may be withdrawn. If it be bloody, the catheter must be tied in, and an india-rubber tube applied by which the urine may drain away. The next thing is to keep the part perfectly quiet, so as to bring about union. With

Fig. 296.—Fracture of the Pelvis through Rami in front, and Sacro-iliac Synchondrosis behind.

this view, a padded belt, or a broad flannel roller, should be tightly applied round the pelvis, the patient lying on a hard mattress, or plaster of Paris may be applied in a manner similar to that recommended for the treatment of fractured spine (p. 810). The knees may then be tied together, and a leather or gutta-percha splint moulded to the pelvis and thighs, so as to prevent all displacement of the fragments. If the urethra have been lacerated, however completely the patient may recover from the fracture, he will most certainly become eventually the subject of the most intractable form of stricture—the traumatic.

Period of Union.—Bony union usually takes place in the pelvis about the end of the sixth week. The patient must, therefore, be kept on his back with absolute immobility of the lower limbs for at least seven or eight weeks. He may then, wearing a padded belt, move about on crutches. However good the union may be, lameness is apt to result from the injury inflicted on the psoas and iliacus muscles, and those that closely bind the thigh to the pelvis, such as the pectineus, the obturators, &c.

Fracture of the Acetabulum is an accident that can occur only as the result of very great violence directly applied to the hip. It may take place in two situations: either through the floor of the cavity, or only through the

rim, a portion of which is detached. It is probably occasioned in most instances by the head of the thigh-bone being driven forcibly against the surface of the acetabulum. Hence, when the rim is broken, it is usually the posterior part that is detached, and the head of the femur slips out upon the dorsum ilii.

Fracture through the floor of the acetabulum is usually complicated with such extensive comminution of the pelvic bones and serious internal injury, as to be soon followed by death. In the University College Museum is a preparation of a fracture of the acetabulum, with comminution of its floor and of the ilium. Sanson and Astley Cooper have seen the bone resolved into its three primitive parts; and in some cases the comminution has been so great that the head of the femur has been thrust into the pelvic cavity. In such extensive and grave injuries as these, the Surgeon can do little more than support the pelvis with a padded belt, and place the limb on a long splint.

When a portion of the rim of the acetabulum is detached, as the result of direct violence, the head of the femur will slip out upon the dorsum ilii, and the signs of one of the forms of dorsal dislocation will manifest themselves. In a case of this kind, in a muscular man aged about thirty, which was under my care, the shortening and inversion of the limb and displacement of the head of the bone towards the sciatic notch were all well marked. Traction readily effected reduction, with distinct crepitus; but, as soon as extension was discontinued, the head of the bone slipped back into its former position.

The **Treatment** consists in the application of the long splint with a broad padded belt, so as to secure steadiness of the head of the bone. But with every care a return of displacement will readily take place, and an unsatisfactory result can scarcely be avoided; shortening of the limb, and consequent lameness, being almost inevitable.

FRACTURES OF THE SACRUM are excessively rare, except as the result of gunshot injury. When occurring from other causes, such as falls, they are almost invariably associated with fracture of the pelvic bones, and then they have always been fatal. The records of surgery contain but very few observations, probably not more than six or eight, of uncomplicated fracture of the sacrum arising from other causes than gunshot. I have had two cases of fracture of the sacrum under my care, both of which had a rapidly fatal issue. In one there was also fracture through the pubic bone; in the other, the sacrum was the only bone injured. In that case, the fracture was the result of a blow on the lower part of the back from the buffer of a railway carriage. The preparation is in the University College Museum. The only other preparation with which I am acquainted is one in the Museum of the College of Surgeons. These fractures are almost invariably transverse with displacement forwards of the upper margin of the lower fragment. This was the case in both the instances under my care; but Richerand has published a case in which the bone was split vertically in consequence of a fall on the face; and crucial and multiple fractures of it have been described by others. The injury can necessarily arise only from severe direct violence, and is attended with much extravasation and pain, together with neuralgia along the course of the posterior sacral nerves, which may be implicated in or irritated by the fracture. The *Treatment* is the same as for fractured pelvis, and consists in the application of a padded pelvic band.

THE COCCYX, though more exposed, is seldom broken. But fracture of it

ay occur from falls backwards, or from direct blows on the part, the tip being ent forcibly forwards. The displacement forwards is maintained by the action f the coccygei. The pain in these cases is excessively severe, owing to the ruising of the ligamentous and tendinous expansions that cover the bone. It greatly increased in sitting and walking, and in defæcation, or in any iolent expiratory effort, as sneezing or coughing. It is sometimes removed n reducing the displaced fragments by pressure through the rectum, but it ay continue for months or years. South relates the case of a gentleman who roke his coccyx by sitting on the edge of a snuff-box, and who suffered such evere pain, that he was obliged to wear a pad on the tuberosity of each chium, in order that the coccyx might be free from pressure when he sat.

Under the term **Coccydynia,** J. Y. Simpson described a painful affecon of the coccyx and its neighbouring structures, which occurs chiefly in omen, commonly as the result of injury, and is often very severe and perstent, so as to prevent the patient from sitting, or even walking with comfort. he pain closely resembles that occasioned by fissure or ulcer of the rectum. t usually arises from a blow on the part, but appears sometimes to originate ndependently of external violence.

In some cases the coccyx may be in its normal position, but in others the hole bone is found to have been displaced, and to be bent forwards almost at ght angles to the sacrum. It can be felt projecting into the rectum, and is aintained in its abnormal position chiefly by the action of the coccygei. his condition is in fact rather a dislocation than a fracture. The bone can asily be forced into its normal position with the finger in the rectum, but the isplacement returns as soon as the pressure is removed.

The **Treatment** recommended by Simpson consists in the free subutaneous division, by means of a tenotome, of the muscular and tendinous tructures connected with the coccyx. The section is made first on one side, hen on the other, and finally around the tip, so as completely to isolate the one. I have often performed this operation, and have as often as not been isappointed in the results. When it succeeds the good effects are immediate. When it fails the bone may be removed by a longitudinal incision over its iddle, exposing its posterior surface. This operation is free from danger, nd may give relief, but is not certain in its results.

FRACTURES OF THE THIGH-BONE may occur in the Upper Articular End f the bone, in its Shaft, or in its Lower End. In these different situations, very possible variety of fracture is met with.

1. **Fractures of the Pelvic End of the Bone** may be divided into those hat occur *through the Neck Within the Capsule* of the joint, those that occur *Outside the Capsule*, and those that implicate the *Trochanters* alone.

Intracapsular Fracture of the Neck of the Thigh-bone may be either imple, the bone being merely broken across; or impacted, the lower portion f bone being driven into the upper fragment.

This intracapsular fracture may almost be looked upon as an injury peculiar o advanced life, being but seldom met with in persons under fifty. Thus Astley Cooper states that, of 251 cases with which he met in the course of his ractice, only two were in persons below this age. It may, however, happen t an early period of life; Stanley has recorded the case of a lad of eighteen who met with this injury, and Hamilton has described it as occurring in a girl ged sixteen and in a man aged twenty-five. A remarkable circumstance in

connection with this accident is, that it commonly happens from very slight degrees of violence, indeed almost spontaneously. Thus, the jarring of the foot in missing a step in going downstairs, catching the toes under the carpet, tripping upon a stone, or entangling the foot in turning in bed, are sometimes sufficient to occasion it.

Cause.—The occurrence of this fracture in old age is owing indirectly to the changes in structure, shape, and position of the head and neck of the femur with advancing years. The cancellous structure becomes expanded, the spaces large and loaded with soft fat. The compact structure becomes thinned, and proportionately weakened, especially about the middle and under part of the neck, which, appearing to yield to the weight of the body, is shortened; and the angle between the neck and the shaft is generally said to become lessened, although the investigations of Humphry throw considerable doubt on this

Fig. 207.—Intracapsular Fracture of the Neck of the Femur.

* Fig. 208. — Attitude of Limb in Intracapsular Fracture of the Neck of the Thigh-Bone.

belief. In consequence of these changes it becomes less able to bear any sudden shock, and snaps under the influence of very slight degrees of violence. When it breaks, the capsule may remain uninjured, but the prolongation of it which invests the neck of the bone is usually torn. In some cases, however, this cervical reflection is not ruptured, the lower portion especially often remaining for some time untorn, but at last giving way under the influence of the movements of the limb, or from inflammatory softening.

The fragments are almost always so separated that the fractured surfaces are not in apposition; the upper end of the lower fragment is drawn above and behind the head of the bone, and at the same time is twisted so that its broken surface looks forwards. The head remains in the acetabulum, attached by the ligamentum teres, and sometimes preserving a connection with the lower fragment, through the medium of some untorn portions of the fibrous membrane investing the neck. R. W. Smith has observed that in some instances the two

fragments become interlocked or as it were dovetailed into one another, in consequence of the line of fracture being irregular and dentated.

Signs.—These are, alteration in the shape of the hip, crepitus, pain at the seat of injury and inability to move the limb, with shortening and eversion of it. These we must consider separately, as important modifications of each are sometimes noticed. From the indirect and slight nature of the violence which caused the injury there are no signs of superficial bruising over the hip.

The **Alteration in the Shape of the Hip** is evidenced by flattening of the part. The trochanter is not so prominent as usual, and is approximated to the crest of the ilium; and, on rotating the limb, it is felt to roll under the hand in a smaller circle than on the sound side. In the sound limb, the trochanter describes the segment of a circle having a radius equal to the length of the head and neck of the bone; on the injured side, the circle has a radius equal only to the length of that portion of the neck that still remains attached to the shaft of the bone. During this examination *crepitus* will usually be felt, though this occasionally is very indistinct and even absent, more especially if the limb be not well drawn down so as to bring the fractured surfaces into apposition; and great *pain* is produced by any movement of, or pressure upon, the joint.

The **Attitude of the Limb** is so peculiar, as in general to indicate at once what has happened. There is a striking appearance of helplessness about it. As the patient is lying on his back, it is everted, with the knee semi-flexed; the patient's attempts to lift it up are ineffectual, and he at last ends by raising it with the toe of the opposite foot, or with his hands. In the upright position the injured limb hangs uselessly, with the toes pointing downwards, and the heel raised and pointing to the inner ankle of the sound side (Fig. 208). In some cases, however, the patient can lift the limb somewhat, but with much exertion, from the couch on which he is lying; or can even manage to walk a few paces, or to stand for a few minutes upon it, with much pain and difficulty. This is owing either to the cervical reflection of the capsule being untorn, or else to the fragments having become impacted; and it usually occurs in those cases in which the other and more characteristic signs of this fracture are not well marked.

Eversion of the limb is an almost invariable symptom, and is most marked in those cases in which the shortening is most considerable. This eversion has usually been attributed to the action of the external rotator muscles, which are inserted into the upper end of the lower fragment. But I cannot consider this as the principal cause; for, not only is it very difficult to understand how these muscles can rotate the limb outwards after their centre of motion has been destroyed by the fracture of the neck of the femur, their action being rather in a direction backwards than rotatory under these circumstances; but we find that the limb falls into an everted position in those cases in which, the fracture being in the shaft and altogether below the insertions of these muscles, no influence can be exercised by them on the lower fragment. I look upon eversion in cases of fractured thigh as being simply the natural attitude into which the limb falls when left to itself. Even when the bone is unbroken, eversion takes place spontaneously whenever muscular action is relaxed, as during sleep, in paralysis, or in the dead body; and in the injured limb, in which there is, as it were, a suspension of muscular action, it will occur equally. Indeed, the shortening that takes place will specially tend to relax

the external rotators, and thus still more prevent their influencing the position of the limb.

Inversion of the foot in cases of intracapsular fracture has sometimes been noticed. I have seen two instances; Smith, Stanley, and other Surgeons, have also recorded cases. This deviation from the usual symptoms of this injury has been attributed by some to the cervical reflection of the capsule not having been torn through at its inner side, but that, as Stanley observes, while it may prevent eversion, cannot occasion inversion; by others it has been attributed to the fact of the lower fragment in these cases being found always in front of the upper one. This circumstance, which is much insisted on by R. W. Smith, appears to me to be rather the result than the cause of the inversion; for any traction inwards of the lower fragment by the adductor muscles of the thigh would have a tendency to draw the upper end of this fragment to the anterior, or in other words, the inner side of the upper one. I am rather disposed to think that this inversion is owing, in some cases at least, to the external rotators being paralysed by the violence they receive from the injury that occasions the fracture, and that thus the adductors, acting without antagonists, draw the thigh, and with it the leg, inwards. In both the cases that came under my observation, and in some of those that have been published, the fracture resulted from severe direct injury to the hip, and was not occasioned by the patient jarring his foot, or by any direct violence operating at the end of the limb.

The **Shortening** is at first seldom more than from half an inch to an inch; it cannot, indeed, very well exceed the width of the neck of the bone, as the capsule is usually not torn through. After the fracture has existed some time, the capsule of the joint may yield, allowing greater separation between the fragments, and then it may amount to two, or even two and a half, inches. It not uncommonly happens that the shortening, which is at first but very slight, about half an inch, suddenly increases to an inch or more; this is accounted for on the supposition that the cervical reflection of the capsule, which had not at first been completely ruptured, at last gives way entirely; or it may be owing to the fragments which were originally interlocked becoming separated. It is in those cases in which there is but slight separation of the fragments, and consequently little shortening, that the other signs of fracture are not very strongly marked, and that the patient preserves some power over the movements of the limb.

The ordinary method of measuring the limb is to apply one end of the tape to the anterior superior spinous process of the ilium, and the other to the inner malleolus. The two limbs must be put as accurately as possible in the same position, as flexion and extension will considerably alter the distance between these points. Two other methods have been recommended for more accurately determining the position of the trochanter, both of which are of great diagnostic value in injuries, whether fractures or dislocations, of the hip. The first is known as Nélaton's line; the second, as Bryant's ilio-femoral rectangle.

Nélaton's Diagnostic Line (Fig. 209 A, A) consists of a line drawn from the anterior superior spine of the ilium to the most prominent part of the tuber ischii. The importance of this line is, that when the head of the femur is in its normal situation, the line touches the summit of the trochanter when the thigh is raised to a right angle with it. If the trochanter be

displaced in any direction, a corresponding change in its relation to this line will ensue. This mode of measurement is, however, open to the fallacy that abduction raises the trochanter above the line, and adduction brings it below it.

Bryant's Ilio-femoral Rectangle (Fig. 209, A, D, C) is formed by placing the patient in the recumbent position; then, drawing a line (A, B) from the anterior superior spine of the ilium across the outer surface of the hip vertically to the horizontal plane, and a second line (C, D) from the summit of the trochanter upwards at right angles to the first line. In all cases in which the neck of the femur is shortened or the head of the bone displaced upwards, as in some dislocations, the test line (C, D) will be found in measurement to be shorter than on the sound side. In this method there is the same fallacy as

Fig. 209.—Nélaton's Line—dark. Bryant's Ilio-femoral Rectangle—dotted.

in Nélaton's—that abduction and adduction of a healthy limb alter the length of the test line.

Another method of measurement has been recommended by Giraud-Teulon which, although somewhat complicated, appears to be free from all source of error. It is founded upon the fact that the middle of Nélaton's line corresponds to the centre of the acetabulum. Any shortening of the femur by fracture, or any dislocation, will necessarily alter the distance between the lower end of the femur and this point. The measurement is thus carried out. Find the distance from the anterior superior spinous process to the tuberosity of the ischium, and from the same point to the inner condyle, and from the tuberosity to the inner condyle. Then draw a triangle on a sheet of paper, the three sides of which are equal to these three measurements; find the middle point of the line corresponding to the measurement between the tuberosity and the spine, and from that draw a line to the apex of the triangle. This line corresponds to the distance of the inner condyle from the centre of the acetabulum, and must be contrasted with a similar line obtained by measurement of the sound side. This mode of measurement is most useful in cases of dislocation and disease in which abduction or adduction with flexion is often met with.

Whatever mode of measurement is adopted, the Surgeon must never neglect to examine and compare the two sides carefully and simultaneously, with one hand on each hip.

the external ... in old people, though trifling at first,
of the limb. ... and the injury frequently terminates
Inversio ... pneumonia, an asthenic state of
noticed. I ... ment to bed. Hence this injury
have also ...
injury has ... these fractures turns in great measure
having be ... of union, and on the constitutional
it may p ... no union occurs, but the head of the
attributed ... hollowed into a smooth, hard, cup-
in front ... has become rounded off and polished,
R. W. Sm ... majority of cases, however, union takes
sion; for ... to two causes:—first, that the
of the th ... n: and secondly, that the supply of
the ante ... the vessels of the ligamentum teres is
disposed ... of callus.
external ... does take place. This can happen only
that oc ... ligament being untorn, or the fracture
antago ... in apposition, and the supply of blood to
that ca ... augmented by that carried to it through the
lished. ... between the fragments in the process of
occasio ... the head of the femur will usually be found
at the ... that it looks towards the lesser trochanter
The ... fragment.
it can ... do not unite by bone unless the fragments
capsu ... to confine the patient to bed for any long
the ... amount of *shortening*, indicate considerable
frag ... or if the patient be very aged and feeble
not ... confinement to bed most commonly proves
abou ... which it exercises on the general health
for ... inducing bed-sores. It is therefore best to
not ... two or three weeks, until the limb has become
owi ... tendency to muscular spasms, which is often
It i ... away. The patient should be laid flat on his
and ... suitable couch properly provided with a pan for
ver ... This is most important, for if the urine and
mo ... patient so as to wet the buttocks, bed-sores will
... utmost attention to dryness and cleanliness
to ... them. The knees should be bent at an angle of
im ... tied together. At the end of from two to four
sa ... be fitted to the hip, and the patient should be
h ... There will be lameness during the remainder
... of a stick and a properly adjusted splint, but little
...
... of treatment is the application of a properly fitted
... hip-splint. (See Diseases of the Hip, Vol. II.
... the patient must be kept in bed, either with the legs
... or with a weight-extension apparatus to diminish
... to steady the limb and prevent eversion. As
... applied, if the patient be old and feeble, he may be got
... may move about on crutches. If there is no fear

of hypostatic congestion of the lungs he is better in bed for a fortnight or three weeks.

When the fragments do not appear to be much separated, there being but little shortening and indistinct crepitus, and more particularly if the patient be not very aged and in other respects sound and well, an attempt may be made to procure osseous or at least close ligamentous union. This is most likely to be obtained by the use of Thomas's hip-splint, with prolonged rest in bed, but should this apparatus not be procurable the long thigh-splint may be applied in the same way as for fracture of the shaft ; or if this cannot very readily be borne, recourse should be had to the double inclined plane, with a padded belt strapped round the hips, the patient being kept in bed for at least two or three months, when a leather splint may be put on, and he may move about on crutches. During the whole of the treatment, a generous diet should be ordered, and the patient kept on a water-bed or cushion. In these fractures of the neck of the femur, the starched bandage will often be found most useful. It may be applied as in fractured thigh, but should have additional strength in the spica part. When the patient begins to move about, great comfort will be derived from the use of a well-padded leather or gutta-percha case, made in two pieces, one for the hip, the other for the thigh, united by a hinge-joint, which can be set fast in the erect posture by dropping a slot over it. When this is raised it can be flexed, so as to allow of the patient sitting in comfort. In old people, this plan of treatment is especially advantageous, as it enables them to sit up or even to walk about, and thus prevents all the ill effects of long confinement in bed.

Impacted Intracapsular Fracture is a rare accident, and can scarcely be distinguished from a similar injury outside the capsule. In it the upper end of the neck is driven into the cancellous tissue of the separated head. In a case under the care of Gay, of the Massachusetts General Hospital, which is recorded by Bigelow, the nature of the injury was proved by *post-mortem* examination, death having occurred from pneumonia at the end of two weeks. The following were the symptoms. The patient, aged 76, fell, striking the right trochanter. He thought he had received only a bruise, and crawled upstairs to bed unaided. Two days after, when admitted to the hospital, the right leg was found to be shortened by half an inch ; the foot was everted, and could not be inverted beyond the perpendicular ; the thigh could be flexed and extended without difficulty, but with pain ; the trochanter was less prominent than that of the other side. Before he died he could raise his foot some inches from the bed without assistance. After death the head was found to be "broken from the articular extremity of the neck, which was short and thick, the fracture behind being almost at the line of junction of the articular cartilage and the bone, while in front it ran irregularly across the neck from a quarter to half an inch below this line. The head was bent obliquely backwards and downwards towards the lesser trochanter—the tilting of the head opening the fracture on the outside of the neck—and was so firmly impacted that considerable force was required to withdraw it." Bigelow also records a case under the care of Cushing, of Dorchester, U.S.A., in which the exact nature of the impacted fracture was proved by examination after death, which occurred nearly five years after the accident. The patient was seventy years of age. The fracture closely resembled that just described, and union had taken place by bone. It is

evident that these cases cannot be distinguished during life from impacted fractures of any other part of the neck. The *treatment* is the same as that of extracapsular impacted fracture.

Extracapsular Fracture of the Neck of the Thigh-Bone commonly occurs at an earlier age than the injury which has just been described, but it is met with also at advanced periods of life. It is the result of direct violence to the hip, and is equally common in both sexes. In young subjects it occurs only as a consequence of great violence, but in old people it may result from a simple fall on the hip.

This fracture may be of two kinds: the *unimpacted* or the *impacted*. In both cases the neck of the bone is commonly broken at, or immediately outside, the insertion of the capsule of the joint. The fracture is almost invariably comminuted when it occurs in a young subject or as the result of great violence. Indeed, I have never seen a case of this kind in which the great trochanter was not either detached or splintered into several fragments. In many instances the lesser trochanter is detached, and the upper end of the shaft injured (Fig. 210). This splintering of the trochanter is due to the same violence that breaks the bone forcing the lower end of the neck into the cancellous structure of this process, and thus, by a wedge-like action, breaking it into fragments. When the neck continues locked in between these, we have the impacted form of fracture. In older subjects, however, whose bones are atrophied and softened by age, it is common to meet with extracapsular impacted fractures without any splintering of the trochanter.

Fig. 210.—Simple Extracapsular Fracture of the Neck of the Thigh-Bone: Detachment of the Trochanter.

The *Signs* of extracapsular fracture vary according as it is simple or impacted; but in both cases they partake of the general character of those of fracture within the capsule. The individual signs, however, present certain well-marked differences.

The hip will usually be found *bruised and swollen* from extravasation of blood, often considerably so.

In the **unimpacted fracture**, the *crepitus* is readily felt on laying the hand upon the trochanter, and moving the limb. The separate fragments into which the trochanter is splintered may occasionally be felt to be loose. The *pain* is very severe, and greatly increased by any attempt at moving the joint, which to the patient is impossible. The *eversion* is usually strongly marked, and the position of the limb is characteristic of complete want of power in it. *Inversion* occurs more frequently in this fracture than in that within the capsule. Smith found that of 7 cases of inversion of the limb in fractures of the neck of the femur, 5 occurred in the extracapsular fracture; and in 15 cases of intracapsular fracture, this condition was met with in 3. When there is much comminution of the trochanter, the foot will sometimes remain in any position in which it is placed, but generally it has a tendency to rotate outwards. The *shortening* of the limb is never less than an inch and a quarter, and sometimes amounts to two inches and a half, or three inches.

In the extracapsular fracture of the neck of the femur, death occasionally ults from the severity of the injury, and the consequent shock to the tem. The extravasation of blood into the tissues of the limb has been own to be sufficient to account for the fatal result. When the patient es, bony union takes place, large irregular stalactitic masses being commonly own out by the inferior fragment, so as to overlap the several splinters of ie and thus give the appearance of great thickening and projection of the chanter. This callus is most abundant posteriorly in the intertrochanteric ce (Fig. 214).

The **Impacted Extracapsular Fracture** of the neck of the femur urs when, in consequence of a heavy fall on the hip, the neck is broken oss at its root, and the upper fragment is driven into the cancellous ucture of the lower one, often splitting up and detaching the trochanter

Figs. 211, 212.—Sections of Impacted Extracapsular Fractures of Neck of Femur; showing the degree of Impaction and of Splintering in different cases.

igs. 211, 212). It is not an uncommon accident about middle life, and n in old age. Its most common cause is a severe fall, as upon the ice in ting.

The *Signs* of this form of fracture are often somewhat negative, rendering diagnosis extremely difficult. There is *pain* about the hip, with *eversion* of foot. The degree of eversion varies considerably; sometimes it is so great t the outer side of the foot can scarcely be raised from the bed without ing the patient intense pain, and in other cases it can be recognized only by limitation of inversion when contrasted with the opposite limb. There is ght *shortening*, usually about half an inch, and never exceeding one inch, l occasionally as little as a quarter of an inch. As a rule, there is no *pitus*, but occasionally, owing to the looseness of the impaction, some may obtained with difficulty. When the impaction is firm, the patient can raise foot a few inches off the couch on which it is laid, and even walk a short tance upon it with a hobbling motion, though with much pain. Some tening over the trochanter is usually perceptible—sometimes an increase in eadth from before backwards—and, on pushing the fingers in deeply behind trochanter, the posterior intertrochanteric fossa can sometimes be felt to filled up. In consequence of the impaction the limb cannot be restored by ction to its proper length, and hence incurable lameness always results m this injury.

The **Constitutional Disturbance** in old people, though trifling at first, often eventually becomes considerable; and the injury frequently terminates fatally, from the supervention of hypostatic pneumonia, an asthenic state of system, or sloughing of the nates from confinement to bed. Hence this injury must always be considered dangerous.

Mode of Union.—The treatment of these fractures turns in great measure upon the view that is taken of their mode of union, and on the constitutional condition of the patient. In some cases no union occurs, but the head of the bone remains in the acetabulum, being hollowed into a smooth, hard, cup-shaped cavity, in which the neck, which has become rounded off and polished, plays as in a socket. In the great majority of cases, however, union takes place by fibrous tissue. This is owing to two causes:—first, that the fractured surfaces are not in apposition; and secondly, that the supply of blood to the head of the bone through the vessels of the ligamentum teres is insufficient for the proper production of callus.

In some cases, however, bony union does take place. This can happen only when, in consequence of the cervical ligament being untorn, or the fracture being impacted, the surfaces are kept in apposition, and the supply of blood to the head of the bone is speedily augmented by that carried to it through the medium of the vascular tissue formed between the fragments in the process of repair. When bony union occurs the head of the femur will usually be found to be somewhat twisted round so that it looks towards the lesser trochanter, owing to the eversion of the lower fragment.

Treatment.—As these fractures do not unite by bone unless the fragments be in good contact, it is useless to confine the patient to bed for any long period, if the signs, especially the amount of *shortening*, indicate considerable separation between the fragments, or if the patient be very aged and feeble. In these circumstances, lengthened confinement to bed most commonly proves fatal by the depressing influence which it exercises on the general health, causing hypostatic pneumonia or inducing bed-sores. It is therefore best to keep the patient in bed only for two or three weeks, until the limb has become somewhat less painful, and the tendency to muscular spasms, which is often very distressing, has passed away. The patient should be laid flat on his back, on a fracture-bed or a suitable couch properly provided with a pan for the reception of the excreta. This is most important, for if the urine and fæces be passed under the patient so as to wet the buttocks, bed-sores will infallibly result. In fact the utmost attention to dryness and cleanliness is needed in order to prevent them. The knees should be bent at an angle of 45° over pillows and the legs tied together. At the end of from two to four weeks a leather splint should be fitted to the hip, and the patient should be allowed to get up upon crutches. There will be lameness during the remainder of life; but, with the aid of a stick and a properly adjusted splint, but little inconvenience will be suffered.

A most excellent mode of treatment is the application of a properly fitted and well-padded Thomas's hip-splint. (See Diseases of the Hip, Vol. II.) Until the splint is ready the patient must be kept in bed, either with the legs bent, as before described, or with a weight-extension apparatus to diminish shortening, and sandbags to steady the limb and prevent eversion. As soon as the splint is applied, if the patient be old and feeble, he may be got out of bed, and, if possible, may move about on crutches. If there is no fear

of hypostatic congestion of the lungs he is better in bed for a fortnight or three weeks.

When the fragments do not appear to be much separated, there being but little shortening and indistinct crepitus, and more particularly if the patient be not very aged and in other respects sound and well, an attempt may be made to procure osseous or at least close ligamentous union. This is most likely to be obtained by the use of Thomas's hip-splint, with prolonged rest in bed, but should this apparatus not be procurable the long thigh-splint may be applied in the same way as for fracture of the shaft ; or if this cannot very readily be borne, recourse should be had to the double inclined plane, with a padded belt strapped round the hips, the patient being kept in bed for at least two or three months, when a leather splint may be put on, and he may move about on crutches. During the whole of the treatment, a generous diet should be ordered, and the patient kept on a water-bed or cushion. In these fractures of the neck of the femur, the starched bandage will often be found most useful. It may be applied as in fractured thigh, but should have additional strength in the spica part. When the patient begins to move about, great comfort will be derived from the use of a well-padded leather or gutta-percha case, made in two pieces, one for the hip, the other for the thigh, united by a hinge-joint, which can be set fast in the erect posture by dropping a slot over it. When this is raised it can be flexed, so as to allow of the patient sitting in comfort. In old people, this plan of treatment is especially advantageous, as it enables them to sit up or even to walk about, and thus prevents all the ill effects of long confinement in bed.

Impacted Intracapsular Fracture is a rare accident, and can scarcely be distinguished from a similar injury outside the capsule. In it the upper end of the neck is driven into the cancellous tissue of the separated head. In a case under the care of Gay, of the Massachusetts General Hospital, which is recorded by Bigelow, the nature of the injury was proved by *post-mortem* examination, death having occurred from pneumonia at the end of two weeks. The following were the symptoms. The patient, aged 76, fell, striking the right trochanter. He thought he had received only a bruise, and crawled upstairs to bed unaided. Two days after, when admitted to the hospital, the right leg was found to be shortened by half an inch ; the foot was everted, and could not be inverted beyond the perpendicular ; the thigh could be flexed and extended without difficulty, but with pain ; the trochanter was less prominent than that of the other side. Before he died he could raise his foot some inches from the bed without assistance. After death the head was found to be "broken from the articular extremity of the neck, which was short and thick, the fracture behind being almost at the line of junction of the articular cartilage and the bone, while in front it ran irregularly across the neck from a quarter to half an inch below this line. The head was bent obliquely backwards and downwards towards the lesser trochanter—the tilting of the head opening the fracture on the outside of the neck—and was so firmly impacted that considerable force was required to withdraw it." Bigelow also records a case under the care of Cushing, of Dorchester, U.S.A., in which the exact nature of the impacted fracture was proved by examination after death, which occurred nearly five years after the accident. The patient was seventy years of age. The fracture closely resembled that just described, and union had taken place by bone. It is

evident that these cases cannot be distinguished during life from impacted fractures of any other part of the neck. The *treatment* is the same as that of extracapsular impacted fracture.

Extracapsular Fracture of the Neck of the Thigh-Bone commonly occurs at an earlier age than the injury which has just been described, but it is met with also at advanced periods of life. It is the result of direct violence to the hip, and is equally common in both sexes. In young subjects it occurs only as a consequence of great violence, but in old people it may result from a simple fall on the hip.

This fracture may be of two kinds: the *unimpacted* or the *impacted*. In both cases the neck of the bone is commonly broken at, or immediately outside, the insertion of the capsule of the joint. The fracture is almost invariably comminuted when it occurs in a young subject or as the result of great violence. Indeed, I have never seen a case of this kind in which the great trochanter was not either detached or splintered into several fragments. In many instances the lesser trochanter is detached, and the upper end of the shaft injured (Fig. 210). This splintering of the trochanter is due to the same violence that breaks the bone forcing the lower end of the neck into the cancellous structure of this process, and thus, by a wedge-like action, breaking it into fragments. When the neck continues locked in between these, we have the impacted form of fracture. In older subjects, however, whose bones are atrophied and softened by age, it is common to meet with extracapsular impacted fractures without any splintering of the trochanter.

Fig. 210.—Simple Extracapsular Fracture of the Neck of the Thigh-Bone: Detachment of the Trochanter.

The *Signs* of extracapsular fracture vary according as it is simple or impacted; but in both cases they partake of the general character of those of fracture within the capsule. The individual signs, however, present certain well-marked differences.

The hip will usually be found *bruised and swollen* from extravasation of blood, often considerably so.

In the **unimpacted fracture,** the *crepitus* is readily felt on laying the hand upon the trochanter, and moving the limb. The separate fragments into which the trochanter is splintered may occasionally be felt to be loose. The *pain* is very severe, and greatly increased by any attempt at moving the joint, which to the patient is impossible. The *eversion* is usually strongly marked, and the position of the limb is characteristic of complete want of power in it. *Inversion* occurs more frequently in this fracture than in that within the capsule. Smith found that of 7 cases of inversion of the limb in fractures of the neck of the femur, 5 occurred in the extracapsular fracture; and in 15 cases of intracapsular fracture, this condition was met with in 3. When there is much comminution of the trochanter, the foot will sometimes remain in any position in which it is placed, but generally it has a tendency ...utwards. The *shortening* of the limb is never less than an inch ...ter, and sometimes amounts to two inches and a half, or three

In the extracapsular fracture of the neck of the femur, death occasionally results from the severity of the injury, and the consequent shock to the system. The extravasation of blood into the tissues of the limb has been known to be sufficient to account for the fatal result. When the patient lives, bony union takes place, large irregular stalactitic masses being commonly thrown out by the inferior fragment, so as to overlap the several splinters of bone and thus give the appearance of great thickening and projection of the trochanter. This callus is most abundant posteriorly in the intertrochanteric space (Fig. 214).

The **Impacted Extracapsular Fracture** of the neck of the femur occurs when, in consequence of a heavy fall on the hip, the neck is broken across at its root, and the upper fragment is driven into the cancellous structure of the lower one, often splitting up and detaching the trochanter

Figs. 211, 212.—Sections of Impacted Extracapsular Fractures of Neck of Femur; showing the degree of Impaction and of Splintering in different cases.

(Figs. 211, 212). It is not an uncommon accident about middle life, and even in old age. Its most common cause is a severe fall, as upon the ice in skating.

The *Signs* of this form of fracture are often somewhat negative, rendering the diagnosis extremely difficult. There is *pain* about the hip, with *eversion* of the foot. The degree of eversion varies considerably; sometimes it is so great that the outer side of the foot can scarcely be raised from the bed without giving the patient intense pain, and in other cases it can be recognized only by the limitation of inversion when contrasted with the opposite limb. There is slight *shortening*, usually about half an inch, and never exceeding one inch, and occasionally as little as a quarter of an inch. As a rule, there is no *crepitus*, but occasionally, owing to the looseness of the impaction, some may be obtained with difficulty. When the impaction is firm, the patient can raise the foot a few inches off the couch on which it is laid, and even walk a short distance upon it with a hobbling motion, though with much pain. Some flattening over the trochanter is usually perceptible—sometimes an increase in breadth from before backwards—and, on pushing the fingers in deeply behind the trochanter, the posterior intertrochanteric fossa can sometimes be felt to be filled up. In consequence of the impaction the limb cannot be restored by traction to its proper length, and hence incurable lameness always results from this injury.

Pathology.—The deformity accompanying this injury has been shown by Bigelow to be due in great measure to the anatomical structure of the femur. If a series of horizontal sections be made of the neck of the bone, "it will be found that at the upper part the anterior and posterior walls are of nearly equal thickness, but that, as we approach the lower surface, the anterior wall becomes of great thickness and strength, while the posterior wall remains thin, especially at its insertion beneath the posterior intertrochanteric ridge, where it is of the thinness of paper." The result of this is that, when severe direct violence is applied to the trochanter, the posterior wall yields, crushes up, and becomes impacted, while the anterior "serves as a sort of hinge upon which the shaft rotates to allow the posterior impaction." This causes the rotation outwards. The shortening Bigelow explains by obliquity of the neck of the femur, which causes the limb to be shortened in proportion to the rotation. That this is the true explanation of the deformity in all the slighter cases of this injury is highly probable. In the more severe crushes of the trochanter,

Fig. 213.—Union in Impacted Extra-capsular Fracture of Neck of Femur.

Fig. 214.—Impacted Extracapsular Fracture of Neck of Femur: Abundant Formation of Callus.

the anterior wall of the neck as well as the posterior may be driven amongst the splintered fragments.

The **Treatment** of the extracapsular fracture may very conveniently and efficiently be conducted by means of the long splint, a padded belt, if necessary, being strapped firmly round the hips underneath it; or the plan recommended by Astley Cooper, of placing the patient on a double inclined plane, with both feet and ankles tied together, and a broad belt, well padded, firmly strapped round the body, so as to press the fragments of the trochanter firmly against one another, will be found an excellent mode of keeping the limb of a proper length, and the fragments in contact. In many cases a Thomas's hip-splint, applied as soon as the swelling has subsided, will be found a most efficient and comfortable apparatus. In impacted extracapsular fracture nothing can be done to diminish the deformity. Solid bony union always takes place, even in aged subjects. The patient remains throughout life more or less crippled, chiefly by the eversion, the amount of shortening being of little consequence.

In these cases a Thomas's hip-splint may be used from the first; or after three weeks' rest in bed a leather splint may be applied, and the patient allowed to move about on crutches.

The **Diagnosis** of the different forms of fracture of the neck of the thigh-bone from one another, and from other injuries occurring in the vicinity of the hip-joint, is a matter of considerable importance, and often of no slight difficulty.

Between the unimpacted intracapsular and the ordinary extracapsular fractures there can be no difficulty in diagnosis; all the signs of the latter being much more strongly marked than those of the former injury, as may be seen by the annexed table, the difference of age and the degree of violence required to break the bone being also important elements in the diagnosis.

Diagnosis between unimpacted Intra- and Extra-capsular Fractures of the Neck of the Thigh-bone.

Intracapsular.	*Extracapsular.*
1. Cause generally slight and indirect, such as catching the foot in the carpet or slipping off the kerb-stone.	1. Cause usually severe and direct violence, such as falling from a height or a blow on the hip.
2. Force usually applied longitudinally or obliquely.	2. Force usually applied transversely.
3. Age, rarely below fifty; most commonly in feeble aged persons.	3. Age, usually below fifty; chiefly in vigorous adults.
4. Pain and constitutional disturbance slight.	4. Pain and constitutional disturbance usually considerable.
5. No apparent injury to soft parts about hip.	5. Considerable extravasation, ecchymosis, and signs of direct injury to hip.
6. Crepitus often obscure.	6. Crepitus very readily felt.
7. Shortening, at first, usually not more than one inch.	7. Shortening at least two inches or more.

The distinction between *intracapsular fracture* and the *impacted fracture of the neck* is also easy. In the former case the crepitus can be obtained by extending and rotating the limb, the eversion is more marked, and the injury occurs usually from indirect violence; in the latter, traction cannot restore the limb to its proper length, crepitus is wanting, and the fracture is always the result of direct violence applied to the trochanter.

In *impacted fractures of the neck of the femur* it is, as a rule, impossible to determine whether the injury is within or without the capsule. The separation of the head and the impaction of the neck into it occur only in old people, and, judging from the few recorded cases, the shortening and eversion are slight. Fracture of the root of the neck with impaction into the trochanter occurs at all ages after middle life. Its symptoms vary from scarcely appreciable displacement to extreme eversion with one inch of shortening. Should the trochanter have been fissured or splintered, this may be ascertained on careful examination, and the nature of the injury could then be recognised with certainty.

Severe contusions of the hip are sometimes followed by eversion of the limb with inability to move it, so that at first sight it might be supposed that the bone was broken. In these cases, however, the absence of shortening and crepitus will always establish the diagnosis. But though no immediate and sudden shortening can occur without fracture, these contusions may be followed at a remote period by shortening of the limb from atrophic changes in the head and neck of the femur. When the injured hip-joint has been the seat of *chronic rheumatic arthritis*, and the limb is already somewhat shortened by the changes that occur in the head and neck of the femur in this disease, the difficulty of diagnosis becomes great; especially as there may also be,

as the result of the disease, some thickening of the trochanter, with rough grating, almost like true crepitus, on moving the joint. Here, however, the history of the case, the fact of the shortening not being of recent occurrence, the possible affection of other joints, the character of the grating and the absence of acute pain with it, will be sufficient to establish the nature of the injury. The diagnosis of these injuries from *dislocations* will be considered in a subsequent chapter.

Occasionally the fracture extends **through the trochanter major and upper part of the shaft** without implicating the neck of the bone. Here there is shortening by about three-fourths of an inch, or an inch, with much eversion, and crepitus is readily felt. This fracture, which unites firmly by bone, must be treated in the same way as the last.

Compound Fractures of the neck of the Thigh-bone can occur only from bullet wounds. In these cases the choice lies between amputation at the hip-joint, resection of the injured portion of bone, or treating the case as an ordinary compound fracture. The choice of the Surgeon, for reasons stated at p. 359, lies between the latter two alternatives, which alone afford a reasonable hope of safety to the patient.

Fracture of the Trochanter Major, by which this process is broken off from the rest of the bone, is described by Astley Cooper, Aston Key, and Nélaton as always being the result of direct violence. It may be single or comminuted. The fragment is usually drawn upwards and backwards, rarely forwards; and more rarely it remains fixed by fibrous bands in its normal place. The symptoms are separation between the fragments, and crepitus, which is most readily obtained by flexing and abducting the thigh and rotating it outwards, at the same time that the fragments are firmly pressed together. There is no shortening of the limb. The exact nature of the injury is often concealed by the swelling from extravasated blood. It is very rare without accompanying fracture of the neck. In children the epiphysis of the trochanter has been known to be separated by direct violence.

2. **Fractures of the shaft of the Thigh-bone** are of very common occurrence, especially in children, forming, according to Bruns, one-quarter of all fractures in children under ten. They steadily decrease in frequency with age. Excluding those implicating the neck, one-third of all fractures of the femur occur under 10, and about the same between 10 and 30.

In adults they are always oblique, unless they are the result of direct violence; in children, especially when the child is very young, the fracture is more often transverse or nearly so. The most common seat of fracture from indirect violence is the middle third, and the obliquity is such that the sharp point of the upper fragment is directed forwards and outwards.

The *Signs* are well marked. There is shortening, usually to a considerable extent, with eversion of the limb, crepitus readily produced, and much swelling from the approximation of the attachments of the muscles. The lower fragment is always drawn upwards, and somewhat to the inner side of the upper, and is rotated outwards. When the fracture is at or above the middle of the thigh, there is a great tendency to angular deformity, in consequence of the projection forwards of the lower end of the upper fragment. In all cases there is this forward projection, and in most an outward displacement, or abduction, as well of the upper fragment. But in some very rare cases, it is drawn inwards as well as forwards.

The common displacement is caused in the following way. The upper fragment is abducted chiefly by the gluteus minimus, it is rotated outwards by the external rotators attached to the trochanter and flexed by the psoas and iliacus. The lower fragment is drawn upwards chiefly by the flexor muscles of the leg and the adductor magnus, and to a less degree by the vasti; it is drawn inwards by the adductor magnus and adductor longus if the latter muscle be attached to it. As the obliquity of the fracture, when from indirect violence, is almost invariably from below, upwards and backwards, and somewhat inwards, it is evident that as the lower fragment is drawn upwards by the muscles passing from above to below the fracture it will tend to the inner side of the limb and will tilt the upper fragment forwards and outwards. In rare cases in which the obliquity is in the opposite direction, the lower fragment may ride in front of the upper.

Synovial effusion into the knee-joint is an almost constant phenomenon in fracture of the femur. It becomes evident soon after the accident and disappears in about a week. It is probably due to a violent strain of the articulation by the same violence that causes the fracture.

The *Treatment* of fractures of the shaft of the thigh-bone may be conducted

Fig. 215.—Liston's Long Splint.

in different ways, each of which presents advantages in particular cases. Whatever treatment is adopted, and however carefully it may be carried out, the Surgeon must not be disappointed if, in the adult, a certain amount of shortening be left. This is more particularly the case where the fracture is oblique and high up; the more transverse and the nearer the condyles the less will be the liability to shortening. In children, union may almost always be obtained without shortening. But a slight diminution in the length of the limb is in reality of no consequence, and gives rise to no inequality of gait; the pelvis remedying this by the obliquity it assumes. It is only when the shortening exceeds half or three quarters of an inch that it is important and occasions deformity. The rotation outwards of the lower fragment, however, if not corrected by treatment, seriously cripples the patient, as it leaves the toes and the patella directed outwards, so that the movements of both the knee and the ankle are rendered almost useless in walking.

1. Extension by means of Desault's or Liston's *long splint* will be found a most efficient plan of treating fractures of the thigh, especially those in the middle part of the bone. The splint must be of sufficient length to extend about six inches below the sole, and nearly as high as the axilla. The long splint is now commonly used merely for extension and to fix the hip and knee-

joints, the fracture being adjusted by short splints applied to the thigh. These are four in number: the anterior, reaching from the groin to the patella; the posterior, from the folds of the nates to the upper part of the ham; the inner, from the perinæum to just above the prominence of the inner condyle; and the outer, from just below the trochanter to above the outer condyle.

Extension is made to the lower end of the long splint by a strong bandage, attached to a wooden "spreader" which is secured to the limb by a broad strip of plaster passing up each side of the leg to above the knee. Counter-extension is made by a perineal band or pad (Fig. 215) attached by stout bandages to the upper end of the splint; the pad should be covered with soft flannel or wash-leather.

In securing the splint to the side of the chest the tendency to its displacement forwards should be counteracted by fixing the bandage to the splint and carrying it round the chest from behind forward. Rotation of the splint must be prevented by supporting it as in Fig. 216, or by fixing a wooden cross-bar

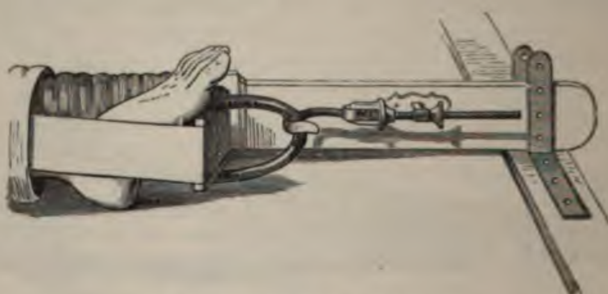


Fig. 216.—Browne's Elastic Catch.

to its lower border. The heel also, by these means, is raised from the bed, and painful pressure upon it avoided.

Various modifications of the method of applying the long splint above described are at times of service. Elastic extension from the foot may be obtained by means of the appliance contrived by Buckston Browne (Fig. 216), which consists of a stout india-rubber ring passed over the wooden "spreader" and attached to the splint by a brass catch, such as is used for the cords of window-blinds.

By applying weight-extension to the limb, and raising slightly the foot of the bed, so that counter-extension is made by the weight of the patient's body, the perineal band which is often very irksome may frequently be dispensed with. A wooden "spreader" is fixed to the limb with plaster as above described, and to this the weight-extension is applied, rotation of the long splint being prevented by a wooden cross-bar.

The bandage employed to fix the long splint to the limb may be replaced by a small sheet folded till it reaches from the groin to the malleoli. It is wrapped round the splint so as to get a firm hold of it, and then brought ... limb, passing under it, and secured by strong pins to the part of ...nd the splint.

...'s knee-splint applied as for disease of the joint (see Disease of

Vol. ii.), with four short splints surrounding the broken bone, forms a excellent apparatus for a fracture of the femur. The end of the splint be slung to a cradle so as to raise it about six inches from the bed, and n of the trunk must be prevented by a broad bandage carried over the and secured to the mattress.

Hodgen, of St. Louis, has introduced the suspension splint for fractures e femur which is represented in Fig. 217. It consists of a light iron , bent at a slight angle opposite the knee. The limb is supported in the by a series of strips of strong bandage attached to its two bars. A r-extension apparatus adjusted to the leg in the usual way is carried to ansverse end of the splint which projects beyond the foot. Finally, the splint is slung by cords which pass over a pulley attached to a firm ht beyond the foot of the bed. Continuous extension and muscular ation are thus obtained. The splint is especially adapted to the treatment

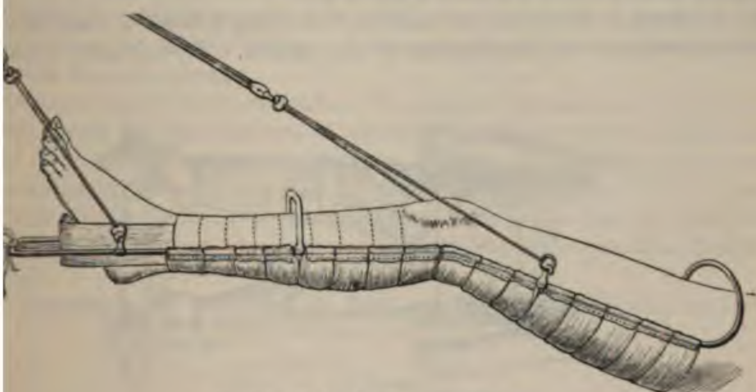


Fig. 217.—Hodgen's Suspension Splint.

ctures near the upper end of the shaft with much displacement forwards of pper fragment, and to fractures low down with displacement backwards lower fragment.

The starched or plaster bandage may be employed in most cases. In ng fractures of the shaft of the thigh-bone with the starched bandage, the ing plan will be found convenient. The limb should be evenly and y enveloped in a layer of cotton wadding ; a long piece of strong paste- , about four inches wide, soaked in starch, must next be applied to the rior part of the limb, from the nates to the heel. If the patient be very ılar, and the thigh large, this must be strengthened, especially at its part, by having strips of bandage pasted upon it. Two narrower strips steboard are now placed, one along each side of the limb, from the hip to nkle, and another shorter piece on the fore part of the thigh. A double of starched bandage should now be applied over the whole, with a g and well-starched spica. It should be cut up and trimmed on the d or third day, and then re-applied in the usual way. With such an atus as this I have treated many fractured thighs, both in adults and in en, without confinement to bed for more than three or four days, but as it is better not to apply the starched bandage before the end of the

second week (Fig. 164). The points to be particularly attended to are, that the hinder pasteboard splint be very strong, at the upper part especially, and that the spica be well and firmly applied, so that the hip and the whole of the pelvis may be immovably fixed.

5. The fracture may be treated by simply relaxing the muscles of the limb. This is effected by laying it upon its outer side, flexing the thigh to nearly a right angle with the body, and the leg upon the thigh, and supporting the limb in this position by an angular wooden or leather splint, extending from the hip to the knee or outer ankle, and by a short inside thigh-splint. This position I have occasionally adopted in fractures about a couple of inches below the trochanters, in which there is a great tendency to the projection outwards of the lower end of the upper fragment, and I have found these cases turn out better in this way than on any other plan of treatment. If there is much shortening a weight-extension apparatus may be applied by means of strapping fixed to the lower part of the thigh.

In *fractures of the femur in children*, it is often difficult to maintain good position, owing to the restlessness of the patient. In such cases Hamilton

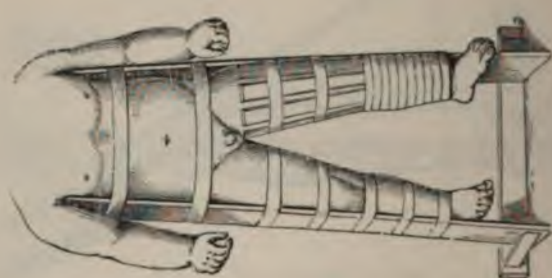


Fig. 218.—Hamilton's Splint.

recommends that a long splint be applied to the sound thigh as well as to the broken one. The two splints are connected at the bottom by a transverse bar (Fig. 218), and some short splints must be put round the thigh to fix the broken bone. I can speak from experience of the very great advantages of this method in young children. The child can be taken up and turned over with the splint without disturbing the fracture in the slightest degree.

Another excellent plan is that recommended by Bryant of applying a back-splint from the heel to the nates and short splints on the sides and front of the thigh, strapping by means of which extension can be made having been previously fixed to the leg. Both limbs are then slung up to a cradle, so as to keep them at right angles to the body. By this means the bandages are kept out of the way of the evacuations passed into the bed, and the weight of the body acts as a constant counter-extending force.

The Treatment of Compound and Comminuted Fracture of the Thigh-bone will vary according as the injury arises from gunshot, or is an accident of civil life. In the former case, for reasons stated at p. 358, amputation should at once be performed if the fracture be below the upper third of the bone. When the upper third is splintered, the result of amputation is so very unsatisfactory that the patient may have a better prospect of recovery if the

limb be treated in splints, and an endeavour made to save it, disarticulation at the hip-joint in such cases being almost invariably fatal.

When a compound fracture of the thigh-bone occurs from one of the common accidents of civil life, even if it be comminuted, the line of practice is not so defined. The course which the Surgeon adopts must be influenced by the extent of injury done to the soft parts, more particularly to the main blood-vessels of the limb. If the integuments and muscles be extensively torn and lacerated, or if there be reason to believe that the femoral vessels have suffered, amputation must be performed. But if the wound be but small, made by the perforation of the bone rather than by the violence which occasioned the fracture, and if the vessels be uninjured, an attempt must be made to save the limb, which should be put up in Thomas's hip-splint, or in the long bracketed splint, and treated with the strictest attention to drainage and to the prevention of decomposition. In cases of compound fracture, where the wound is in the posterior and outer part of the limb, I have found a long thigh-splint, bracketed opposite the seat of injury, the most convenient apparatus, enabling the limb to be kept of a proper length, and the wound to be dressed at the same time.

The treatment of the complication of a *wound of the main artery*, femoral or popliteal, with and by a fracture of the thigh-bone, will vary according as the injury is compound or simple. Such an accident, complicating a compound fracture, would probably be a case for immediate amputation. If the fracture be simple, and a diffused traumatic aneurism form in the ham or lower part of the thigh, we must treat the latter in accordance with the principles laid down at p. 548.

In discussing the treatment of these accidents, in which the question of

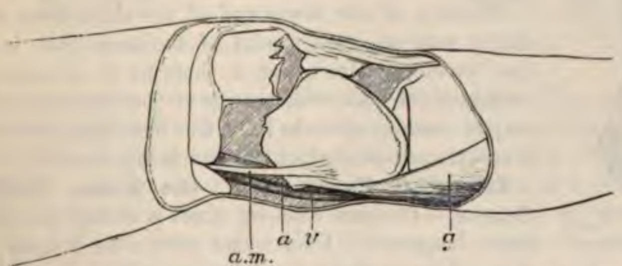


Fig. 219.—Diagram to Illustrate the Displacement which follows Transverse Fracture of the Femur just above the Condyles. *g*, gastrocnemius; *a.m*, adductor magnus; *a*, artery; *v*, vein.

amputation of the thigh is raised, I cannot too strongly state my conviction that, unavoidable as it undoubtedly is in some cases, as the only alternative left to the Surgeon, this operation, when practised primarily *for compound fractures of the thigh-bone*, is one of the most fatal in surgery, and should accordingly not be too hastily resolved upon.

3. Fractures in the Vicinity of the Knee-joint.—The lower end of the thigh-bone may be broken across transversely, immediately above the condyles, and occasionally this may be complicated by a vertical fissure separating the condyles from each other, and extending into the knee-joint. In other cases, the fracture extends through one of the condyles, detaching it

from the shaft of the bone. The readiness with which crepitus can be felt, the line of fracture made out, and the displacement removed by lateral pressure, at once determine the nature of this accident.

When the femur is fractured transversely immediately above the condyles, the lower fragment is powerfully flexed by the gastrocnemius, plantaris, and popliteus muscles, causing its upper extremity to project backwards into the ham, while its lower end of the upper fragment rests on its anterior surface. Thus, although the limb may apparently be extended, the knee-joint is in reality flexed. If a limb in this condition were put up on a long splint and extension made, the displacement would be increased, and non-union of the fracture would very likely result; or, if union did occur, the usefulness of the limb would be most seriously impaired. By putting the limb on a double inclined plane in a flexed position, the deformity is at once removed, and the fractured ends are brought into apposition; or this result may be obtained by the use of Hodgen's suspension splint. Bryant has recommended in these cases that the tendo Achillis should be divided, and in case the double inclined plane failed to overcome the deformity, this might be of use. The displaced lower fragment in these cases must always come into dangerous proximity to the popliteal artery. Should that vessel be wounded a diffuse traumatic aneurism may rapidly form, and must be treated on the principles laid down on page 548. In some cases though the vessel has escaped an actual wound, gangrene has occurred from pressure on the artery and vein. In others a circumscribed popliteal aneurism has formed at a later period.

Fig. 220. — Impacted Fracture of Lower End of Thigh-bone.

Fracture of the lower end of the thigh-bone communicating with an open wound of the knee-joint is usually a case for amputation; but if there be no extensive comminution of the bone or laceration of the soft parts, an attempt may be made to save the limb, free drainage, strict antiseptic precautions, and perfect fixation being essential.

Impacted Fracture of the Lower End of the Femur.—In these cases the shaft is always driven into the lower fragment. I have had several such cases under my care. In one, the upper fragment, which was very oblique, was firmly driven into the cancellous structure of the lower one (Fig. 220). In another case, the condyles of both thigh-bones were splintered into a number of fragments, amongst which the shafts were impacted. Excellent union, however, took place, the skin having been uninjured. The diagnosis is not always easy, as unnatural mobility and crepitus may both be wanting; and in many cases, either from a fissure extending downwards or from the bruising at the time of the accident, effusion occurs into the knee-joint, which still further conceals the nature of the injury. The most characteristic feature in these cases is the shortening, and later on, as the swelling subsides, the deformity at the seat of fracture may be clearly recognised.

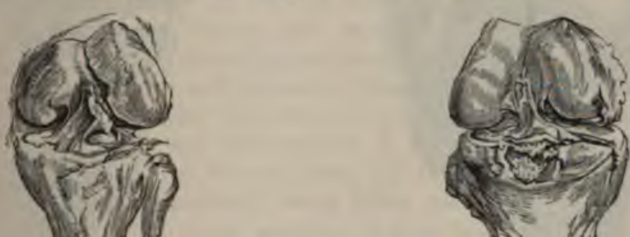
Separation of the Lower Epiphysis of the Femur is not an uncommon accident in children. The wide surfaces are seldom completely separated, and the nature of the injury is further obscured by effusion into the joint; but it

can usually be recognised by seizing the shaft of the femur in one hand and the knee in the other, when lateral movement will be recognised, accompanied by the soft crepitus characteristic of a separated epiphysis. The treatment consists simply in supporting the limb for a few days on a back splint, till the swelling has subsided, when a starched bandage or plaster of Paris splint may be applied. Union usually takes place by bone, and is followed by some shortening from interference with growth.

The **Period of Union of Fractures of the Shaft and Lower end of the Femur** is between seven and eight weeks in the adult, at the end of which time the patient may dispense with artificial support. It is, however, always about three months before full use of the limb is regained. In children under ten, union is usually firm at the end of the fifth week.

Fractures in the Knee-joint.—It occasionally happens that a small fragment of one of the condyles of the femur may be chipped off by a violent blow, and become loose in the cavity of the joint. After the inflammation and effusion have subsided, the fragment may be recognised as a loose body in the joint. (See Diseases of Joints : Loose Bodies.)

In violent blows on the upper part of the tibia, or in forcible and extreme flexion of the knee, it sometimes happens that the bony attachment of one of



Figs. 221, 222.—Fracture of Condyles from fall on the Bent Knees.

the crucial ligaments is torn up. In the case from which Figs. 221 and 222 were taken, the patient fell from a great height on the bent knees. In one knee, the anterior crucial ligament had torn up the part of the tibia to which it was attached. In the other, the posterior crucial ligament had torn out a piece of the femur, and the bone was fissured a long way up between the condyles. In the case from which Fig. 223 was taken, the anterior crucial ligament was torn from its attachment, bringing with it a scale of bone from the tibia. These injuries cannot be diagnosed during life. The treatment would be that of a sprain of the knee, with effusion of blood into the joint.

Fracture of the Patella may be the result of direct violence, when the bone is often comminuted, or even broken longitudinally, being split, and the joint being injured. But most frequently it occurs as the consequence of the sudden action of the extensor muscles of the thigh in the attempt a person makes to save himself from falling when he suddenly slips backwards. The knee being semi-flexed, the patella rests on the femur only in its transverse axis, and is readily snapped across, much in the same way as one breaks a stick across some resisting object. All fractures of the patella from muscular action are transverse (Fig. 224). The patient does not break his patella in these cases by falling upon it, but he falls because the patella has been broken by the violent action of the extensors of the thigh in his

efforts to save himself. In consequence of these fractures being occasioned by muscular action, they are more frequent in men, especially about the middle period of life, less common in women, and extremely rare in children. I have once, however, had under my care a child under ten years of age who had a transverse fracture of the patella. It not unfrequently happens, when one patella has been fractured, that the unsteadiness of gait causes the opposite one to be broken by muscular action in an effort to avoid a fall. The same patella may be broken more than once; in the cases that I have seen, the second fracture has always occurred in the upper fragment, a little above the line of the original fracture.

The *Signs* of this fracture are very evident. When it is transverse, and has been produced by muscular action, the fibrous expansion from the vasti, over the

Fig. 223.—Tibial Attachment of Anterior Crucial Ligament torn up.

Fig. 224.—Diagram of position of fragments in fracture of Patella. Eversion of Upper Fragment.

bone, is torn; and the separation between the fragments (Figs. 224, 225), which is much increased by bending the knee (Fig. 226), and the inability to stand or to raise the injured limb, indicate what has happened. When it has been produced by direct violence, the muscles being at rest, there is little or no separation, even though the fracture be transverse, as the fragments are held together by the untorn expansion from the extensor muscles. In such cases, and when it is longitudinal or comminuted, the crepitus and mobility of the fragments point it out. Immediately on the occurrence of a fracture of the patella, the knee-joint becomes distended by effused blood, and later by inflammatory exudation. The swelling assumes the ordinary form of the distended synovial membrane. It usually subsides after a few days' rest.

Mode of Union.—When the patella is fractured transversely by muscular action, it rarely, if ever, unites by bone, except as the result of some operative procedure, although cases have been recorded in which after simple treatment the union has been so close that there was strong reason to believe it was osseous. The failure of bony union is due—first, to the wide separation of the fragments by the action of the muscles; secondly, to the distension of the

ith fluid that prevents their early approximation ; and thirdly, to the
of the torn fibrous expansion from the vasti which hang down between
gments. Lastly, in the normal state, when the limb is extended, only a
ortion of the under surface of the patella is in direct contact with the
eneath. When the bone is broken, the upper and lower borders sink down on the bone in such a way that even if the fragments can be made to meet posteriorly a gap is left in front. In fractures by direct violence, the expansion covering the bone not being torn, the fragments remain in close apposition, and osseous union readily occurs. In the majority of cases of transverse fracture, the fragments remain separated by an interval varying from one-fourth of an inch to an inch ; but in some instances the gap is much greater, amounting even to four or five inches. When the separation does not exceed an inch and a half, the gap is usually filled up by ligamentous tissue, uniting the fragments firmly. In some of the cases, however, in which the separation between the fragments does not exceed this distance, and in most of those in which it extends beyond it, W. Adams has found that the fracture is not

5.— Pa- Side imb,

Fig. 226. — Fracture of Patella. Separation between Fragments increased by bending the Knee.

by any newly-formed fibrous tissue, but that the fragments are bound
r simply by the thickened fascia which passes over the patella, with
s incorporated the bursa patellæ. Adams finds that the aponeurotic
re thus uniting the fragments may be arranged in different ways.
may be adherent to the anterior periosteal surface of both fragments ;
connecting aponeurosis may be reflected over, and be adherent to, both
ctured surfaces ; or, lastly, (and this is the most frequent arrangement,)
necting aponeurosis may pass from the periosteal surface of the upper
nt to the fractured surface of the lower one, to which it becomes firmly

In the majority of cases, when united by aponeurotic tissue, the
nts gape somewhat towards the skin, coming more nearly in contact
orly. Thus it would appear that a patella fractured transversely may
n two ways : most frequently by the intervention of thickened aponeu-
ructure, and next, by a ligamentous or fibrous union. Of 31 specimens
London museums, examined by Adams, it was found that in 15 aponeu-
nion had taken place, in 12 ligamentous union, and in the remain-
the kind of union could not be determined. The aponeurotic union
leaves a weakened limb and an unprotected joint ; for, in conse-
of the separation of the fragments, and the folding in of the fascia, the
can be thrust in between the articular surfaces of the knee.

tment.—The first step in the treatment of fractured patella is to get
he fluid distending the joint ; for until this is done it is impossible in
ses to bring the fragments into close apposition. Under the influence
and the application of evaporating lotions, the fluid will usually be
d under a week, and in most cases it will have sufficiently diminished

to allow the fragments to be brought together a day or so before this. A much more efficient mode of getting rid of the fluid and allowing immediate apposition of the fragments is aspiration of the joint. This mode of treatment was adopted in 1872 by Dubrueil, but a case of suppuration of the joint followed by death raised a prejudice against it. The accident in this case was probably due to inoculation of the joint with septic matter by means of a dirty needle. In the hands of Volkmann, Max Schede, and Heath, who have strongly recommended this treatment, no evil consequences have ever followed.

Fig. 227.—Stellate Fracture of the Patella.

Fig. 228.—Aponeurotic Union of a Fractured Patella: Side view.

Fig. 229.—Fracture of Patella united by ligamentous tissue.

In order to prevent accidents, the needle must be soaked for ten minutes in a 1 in 20 solution of carbolic acid before being used.

When the fluid has been removed or absorbed, the fragments must in some way be kept in sufficiently close apposition for firm ligamentous union to take place. The means adopted to effect this are numerous, and may be classified thus :—1, Position ; 2, Special Splints or Apparatus ; 3, the plaster of Paris Bandage ; and 4, Operative Measures.

1. **Position.**—The upper fragment, which is retracted by the extensor muscles, must be drawn down so as to be approximated to the lower one, which is fixed by the ligamentum patellæ. In order to do this, the leg must be fully extended and the thigh flexed at the hip to relax the rectus femoris. This may be done by placing the patient in a semi-recumbent position and elevating the leg considerably. Whatever apparatus may be subsequently applied, the position of the limb must also be attended to.

2. **Special Splints and Apparatus.**—The simplest mode of treatment is the application of a back splint with a foot-piece. It must extend upwards to the fold of the nates, and be fixed by bandages, leaving the knee exposed. Two rectangular pieces of gutta-percha measuring about two inches from above downwards, and at least one-third of the circumference of the limb in width, are then moulded to the knee, a deep semilunar notch being cut out of each, so that they may accurately fit the upper and lower borders of the

broken bone. These are applied above and below the patella, and approximated and held in position by broad strips of plaster long enough to embrace the limb and the back splint to which they must be fixed. They are applied obliquely in such a way as to steady the lower fragment and to draw the upper downwards towards it. Care must be taken that the pieces of gutta-percha do not press on the upper and lower portions of the patella, lest the fragments be tilted, so that though they are in contact posteriorly they are separated by a considerable interval in front. If gutta-percha be not at hand, pads of lint cut to the same form must be applied beneath the straps. A figure-of-8 bandage may be applied round the limb and splint together. In the place of the gutta-percha and straps of plaster, an apparatus consisting of two broad bands of leather, buckled above and below the knee and united by longitudinal straps, which can be shortened at pleasure, has been employed.

H. O. Thomas, of Liverpool, recommended a plan of treatment which has given excellent results, and has the great advantage of not confining the patient to bed for more than a few days. A Thomas's bed knee-splint (see Diseases of the Knee-Joint), which need not accurately fit the patient provided it be of sufficient length, should at once be applied. The leg is to be retained in position by the usual extension apparatus of adhesive plaster, the ends of the strips being fixed round the bottom of the splint. "To the bandages which secure the extension-plaster round the leg is sewn a piece of elastic webbing with adhesive material spread upon half its length; this being thus fixed below is stretched over the fractured patella and attached by adhesion to the skin of the thigh above the upper fragment of the patella, which it thus constantly draws gently down and exercises also very slight surface pressure over both fragments, pressing them into the space between the condyles of the femur and head of the tibia." The bandages are now applied over the thigh and leg, and a support arranged, either of leather or adhesive plaster, behind the popliteal space, sufficiently tight to hinder any backward strain on the knee-joint. As soon as it can be made, a walking "caliper" knee-splint with a boot must be fitted to the patient; after which he can leave his bed and move about during the remainder of the treatment.

Fig. 230. — Thomas's Knee-splint, applied for Fractured Patella.

3. **Plaster of Paris and Starched Bandage.**—The immediate application of a plaster of Paris bandage after aspiration of the joint has been strongly advocated by Christopher Heath, who has obtained excellent results by this mode of treatment. I have frequently employed the starched bandage without aspiration of the joint, and have in this way obtained very close union without confining the patient to bed after the third day. A back splint of pasteboard is required to fix the knee, and a good pad of lint with a figure-of-8 bandage should be applied above and below the fracture. The action of the pad is much increased by drawing it down and fixing it by two broad strips of plaster.

With any of the foregoing modes of treatment the apparatus must be applied for at least eight weeks, and after its removal some rigid appliance, such as a firm leather splint or a Thomas's caliper splint, must be fitted to the limb and worn for a further period of some weeks or months. If this precaution be not

taken, the union, which at first appeared very close, will gradually yield until in the course of a few months the fragment may be separated by several inches. Thomas maintains that the common cause of failure is insufficient duration of the treatment. He advises that the knee should not be flexed for nine months, and that the patient during the whole of this time should wear a caliper knee-splint. The stiffness that necessarily results from such prolonged rest will, he asserts, always pass off spontaneously, and never requires forcible flexion or other violent means to get rid of it.

4. **Operative Procedures.**—The foregoing methods of treatment are rarely, if ever, followed by osseous union in cases of fracture by muscular action. Various operative procedures have therefore been suggested in order to maintain more accurate apposition of the fragments, and thus obtain union by bone. The simplest of these is by the use of the instrument known as "*Malgaigne's hooks.*" It consists of a pair of sharp double hooks, which, being fixed into the two fragments, can be drawn together by means of a screw. It undoubtedly is a most efficient means of approximating the fragments, but it does not necessarily ensure bony union. This mode of treatment was at one time almost abandoned, owing to the pain, irritation, and occasional suppuration that followed its use. By ordinary antiseptic measures these can be prevented, and consequently the use of the hooks has been revived by some Surgeons.

A bloodless modification of this treatment has been suggested, in which the hooks are inserted into the pieces of gutta-percha before described (p. 628), instead of into the bone.

Exposing the bone by a longitudinal incision, and uniting the fragments by a wire suture, was suggested by Severini, and was first practised in America by Rhea Barton some sixty years ago. The operation was repeated by Cooper and others, but as two cases out of five terminated fatally, it was very properly abandoned. With the introduction of antiseptic surgery it was again suggested as a mode of treatment by Lister, and was first performed in this country by Cameron, of Glasgow, and has subsequently been repeated in a large number of cases. Lister recommends that the wire should be cut short and the ends hammered down, the wound being allowed to heal over it (Fig. 231). Passive motion is to be commenced at the end of the second week. In some cases drainage must be provided during the first few days, by a small incision at the most dependent part of the outer side of the joint, through which a tube may be inserted. A great many most excellent results have been obtained by this treatment, recovery being rapid, union taking place either by bone or by very firm fibrous tissue, and the movement of the joint being unimpaired; but on the other hand there have been at least five deaths since the re-introduction of the operation, and in other cases suppuration, resulting in ankylosis, has followed, and in one at least the patient has had to submit to amputation. It must not be forgotten that under ordinary treatment properly carried out excellent

Fig. 231.—Wire Suture applied to Fractured Patella (vertical section).

results are obtained without the slightest danger to life. In fact it is remarkable how well the patient can use the limb even when the fragments are separated by as much as an inch. It would not seem to be justifiable therefore to recommend this operation as the ordinary treatment of a simple case of recent fracture of the patella. On the other hand it offers the only chance of cure in those cases in which, owing to imperfect treatment, the separation between the fragments is so great that the limb is practically useless. In 45 cases of this kind collected by Jalaguier in 1884 the operation was successful in 22, in 9 the function of the limb was imperfectly restored, in 1 the operation could not be completed, in 11 ankylosis followed, 10 times after suppuration of the joint, and 3 died of acute septicæmia or pyæmia. In operating on such cases the fractured surfaces must necessarily be freshened before being brought together, adhesions between the upper fragment and the femur must be freely divided, and in some it has been found necessary to make free incisions in the extensors before the fragments could be brought into contact. In compound fractures, whenever it is practicable, the fragments should be united by wire sutures.

To sum up, the operation of opening the joint and suturing the bone is not to be recommended as the ordinary treatment of fracture of the patella; but if the patient be willing to run the risks of the operation for the chance of a more rapid and perfect cure, and if the Surgeon be confident of his ability to prevent suppuration in the joint, it is a perfectly justifiable proceeding. In the case of a useless limb from an old fracture, the patient has the choice of submitting to the operation with its attendant dangers or walking with his limb fixed in some rigid apparatus for the rest of his life. In compound fractures there need be no hesitation in suturing the fragments in all cases.

Kocher of Berne has suggested another operation which in his hands has given very good results. He passes a thick silver wire beneath the fragments, through the knee-joint, by means of a long and strong curved needle fixed on a handle. He then twists the two ends together, protecting the skin over the patella with a pad of lint.

A. E. Barker has used with success the following modification of this method, which according to Gilis has also been employed by Lagneau in France. A puncture is made into the joint with a scalpel immediately below the lower fragment, and as much blood as possible evacuated; a stout pedicle needle is passed from this puncture through the joint behind the fragments and brought out through the skin at a second puncture above the upper one; the needle is threaded with stout silver wire and withdrawn; the unthreaded needle is again passed through the same punctures but in front of the fragments, and after being threaded with the other end of the wire is again withdrawn. The fragments which are thus surrounded by the loop of wire are forcibly drawn together, whilst the ends of the wire are twisted on the lower border of the patella and cut off short. The suture remains permanently.

Mayo Robson aspirates the joint and inserts two steel pins, one through the quadriceps tendon above the upper fragment, and a second through the ligamentum patellæ below the lower fragment. The fragments are then drawn together by stout silk passed in a figure-of-8 around the projecting ends of the pins.

These methods have given excellent results, but are justifiable only if

performed with strict antiseptic precautions, and as means of ordinary treatment are open to the same objections as the open methods.

After-Effects of Fracture of the Patella.—Stiffness of the knee often remains to a very inconvenient degree after the treatment of a fractured patella. It is usually remedied by friction and manipulation. Thomas asserts that it is better left entirely to Nature, and states that he has seen it take two years before useful mobility returned. But should it not yield to these minor means, an apparatus consisting of a thigh-and-leg piece of stiff leather, united by angularly hinged lateral iron rods, and having an india-rubber "accumulator" adapted behind, should be worn. The continued traction of the "accumulator" will gradually flex the knee. But, as the knee becomes bent, the close union that may have appeared to exist between the fragments gradually yields, and they often gape more or less widely, much to the disappointment of both Surgeon and patient, the ligamentous band stretching like a piece of india-rubber. This cannot be helped; there is the alternative between a straight and stiff knee with close union, or a flexible and mobile one with gaping of the fragments. After the knee is flexible, lateral hinged splints may be worn without the elastic strap. The limb on recovery is usually perfectly strong, and good for any exercise except jumping.

In **Simple Comminuted Fractures of the Patella**, the result of direct blows or kicks, the fragments are not much separated, and union takes place readily by bone. In these cases, after the inflammation, which usually is rather acute, has subsided, the starched bandage may be applied, and the knee and fragments thus both kept immovable.

Compound and Comminuted Fractures of the Patella, especially if occasioned by bullet-wounds, and opening the knee-joint, are always most serious injuries. Under strict antiseptic treatment, however, the limb can usually be saved. The wound should, if necessary, be enlarged, and any loose fragments of bone removed; if the size and shape of the fragments admit of it, and if there is any tendency to separation, they should be drilled and united by wire sutures. The cavity of the joint should then be syringed out with some efficient antiseptic solution. A drainage-tube must then be inserted on the outer side of the joint. This is best done by passing into the wound a pair of sinus-forceps, or the finger, if the opening is large enough, and making it project at the lowest possible point on the outer side of the joint; it may then be cut down upon and the tube passed. The wound must be dressed with some efficient form of antiseptic dressing and absolute rest maintained. A case of this kind in University College Hospital, which was complicated by a fracture of the thigh about the middle on the same side, progressed under carbolic-gauze dressing exactly like a simple fracture. It was caused by a fall of about thirty feet, the patient coming down upon the bent knee. If the Surgeon has not at hand the means of efficiently carrying out this treatment, as must sometimes necessarily be the case in military practice, immediate amputation would be the safest plan to adopt.

Necrosis of the Patella as the result of fracture is rare. In one such case which was under my care at the Hospital, the patient, a middle-aged man, had met with an ordinary transverse fracture of the patella, which united by ligament; two years after the accident, and without any fresh injury, he came to the Hospital, with necrosis of the outer half of the upper fragment, which was completly detached, and lying in a cavity shut off from the joint. I cut

own upon and removed the necrosed fragment, which appeared to constitute bout one quarter of the patella. No cause could be assigned for the necrosis, xcept defective vascular supply to this part of the bone.

Fractures of the Bones of the Leg.—Both bones of the leg are fre-nently broken simultaneously, the fracture of the fibula being, as a rule, at a igher level than that of the tibia. The fracture is generally situated near he junction of the middle and lower thirds, and the lower fragments are, in he majority of cases, drawn upwards, behind the upper, by the action of the nuscles of the calf; so that the edge of the tibia projects under the skin and nay perforate it. In certain instances, however, the direction of the fracture s such that the lower fragment rides over the front of the upper. The tibia, hough a stronger bone than the fibula, is as frequently fractured, owing to its eing less protected from blows by muscles, and receiving more directly all hocks communicated to the oot. The fractures of the upper art of this bone are usually ransverse, and are caused by lirect violence; those of the ower part are oblique, and are aused by indirect violence. In hese cases the obliquity in the ibia is from before upwards and ackwards, and this increases he tendency of the lower frag-nent to slide up behind the pper. The sharp point of he upper being in front is very apt to wound the skin (Fig. 232). When oth bones are broken, the usual signs of fracture, such as shortening, ncreased mobility at the seat of injury, and crepitus, render the diagnosis asy: but when one bone alone is broken, it is not always a very simple natter to determine the existence of the fracture, as the sound bone, acting s a splint, prevents displacement. If it be the tibia alone that has been roken, the fracture may be detected by running the finger along the subcu-aneous edge, until it comes to a point that is somewhat irregular, puffy, or ender, where by careful examination some mobility and slight crepitus may e detected. When the fibula alone is broken, the thick layer of the peroneal nuscles overlaying its upper two-thirds renders the detection of the fracture lifficult. It can usually be detected by pressing the fibula firmly towards the ibia, when the patient will complain of pain at the seat of fracture, and at the ame time a click may be felt; by shifting the point of pressure, it will be scertained that the pain is always at the same spot. In the lower third, the racture is easily recognized by the same signs that occur in fractured tibia.

Fig. 232.—Anatomical Preparation to show Displacement of Fragments in Fracture of Leg.

The first step in the **Treatment of Simple Uncomplicated Fractures of the Leg** is to place the patient in a comfortable position while the splints re being prepared. This is done by flexing the hip and knee and laying the imb on its outer side with a soft pillow below the knee. In this way the nuscles of the calf, which are the chief cause of displacement, are relaxed. In the treatment of the fracture many kinds of apparatus have been used. In he majority of cases where there is but little displacement and swelling, rdinary leg-splints (Cline's, well padded, are extremely convenient), are

readily applied and keep the bones in good apposition. These may be kept on for the first few days till all swelling has subsided, when they may be replaced by the starched or plaster bandages. In fracture of the leg, indeed, the starched bandage, the Bavarian, or Croft's splint, is especially applicable. The starched bandage should be applied as follows. The limb having been well covered with wadding, a strong soaked pasteboard splint, four inches broad, and long enough to extend from above the knee to six or eight inches beyond the heel, should be applied to the back of the leg. The projecting terminal piece is now to be turned up along the sole of the foot, and two lateral strips adapted, one to each side of the limb. Over this the starched bandage, single or double according to the size of the limb, must be tightly applied. After it is dry, about the end of the second day, it must be cut up and re-adjusted, and the patient may then walk on crutches with the limb slung in front of him. *Arnold's splint* is another apparatus frequently used. It consists of a back splint of tinned iron with a foot-piece extending from just above the knee to the foot. Two wooden side splints are then applied and the whole slung in a cradle. *McIntyre's splint* (Fig. 233) may be found of service in the earlier periods, if there be much ecchymosis or extravasation, as it keeps the limb in an easy position, and allows the ready application of evaporating

Fig. 233.—McIntyre's Splint.

lotions. In applying this splint the angle at which the knee is fixed must be that at which the projection of the lower end of the upper fragment of the tibia seems least marked. The foot must be covered with a flannel sock, well sewn on, from the heel of which a tape passes by which the foot can be slung up to a screw in the foot-piece. After extension has been made I prefer to pass a few turns of a roller through the extension slits on each side, so as to close the space above the heel, and thus prevent the foot falling backwards if the suspension by the sock and tape should yield. The splint, as originally designed, was screwed to a block, but it will be found to give much more perfect rest if the whole apparatus is swung in a Salter's cradle (Fig. 234). In some cases of fracture of the bones of the leg McIntyre's apparatus is not applicable. This is more particularly the case when the fracture is very oblique, from above downwards, and from before backwards; in these circumstances, the fragments cannot be brought into good position so long as the limb is kept extended and resting on its posterior surface; the bones riding considerably, and one or other of the fractured ends often pressing upon the skin in such a way as to threaten ulceration. In these cases division of the tendo Achillis has been recommended, with the view of removing the influence of muscular contraction. This appears to me, however, an unnecessary procedure, and cer-

tainly was not successful in some cases in which I practised it; for although the tendon was exceedingly tense, only temporary benefit resulted, the displacement returning under the influence of the other muscles inserted into the foot. In these cases the bones may usually be brought into good position by flexing the thigh well upon the abdomen, and the leg upon the thigh, and then laying the limb on its outer side on a wooden leg-splint, provided with a proper foot-piece, and keeping it fixed in this position. In most cases the swing-cradle (Fig. 234) will be found a useful and very easy apparatus. In some fractures of the leg in the upper third, the lower end of the upper fragment projects considerably, and cannot be brought into proper position so long as the knee is kept bent; but if it be extended, so as to relax the extensors of the thigh, the bone is readily brought into good position. In fractures of the leg, as in all injuries of a similar kind, no one plan of treatment should be adopted ex-

Fig. 234.—Salter's Swing-cradle for Fractured Leg.

clusively, but the means employed should be varied according to the peculiarities of each case.

In the management of fractures of the leg anywhere near the ankle the foot should be carefully kept as nearly as possible at right angles to the leg. If it be allowed to drop so that the toes point downwards, the stiffness that always follows fracture in this region, will fix it in that position for some time after the fracture is united, and until the false position is corrected by forcible flexion and rubbing, the patient cannot use his leg for walking.

Period of Union.—The time at which all artificial support may be dispensed with is, when both bones are broken, 8 weeks; if the tibia alone is fractured, 7 weeks; if the fibula alone, 6 weeks.

Complications of Simple Fracture of the Leg.—In addition to the complications common to all fractures, those of the leg are occasionally attended with injury to the main vessels. The consequences of this accident, and its treatment, have already been discussed (see p. 547 *et seq.*). Venous thrombosis occurs more commonly during the treatment of this fracture than in any other (see p. 550).

Compound Fractures of the Tibia are of more frequent occurrence than similar injuries of any other bone in the body. This is owing to the thin covering of soft parts over the anterior and inner aspect of the bone, and to

the fact of the fracture usually being oblique ; so that the sharply pointed end of the upper fragment is likely to be thrust through the integument when the lower part of the limb falls backwards as the injured person attempts to rise or is being raised from the ground. The fracture may also, of course, be rendered compound by the same direct violence that breaks the bone. The treatment must be carried out according to the principles set forth on p. 547 *et seq.* Hæmorrhage from one of the main vessels is a rare complication and must be treated according to the rules laid down on p. 555.

Fractures in the Vicinity of the Ankle-Joint are among the most common injuries of the bones of the lower extremity. They are usually occasioned by twists of the foot, by slipping off the kerb, by jumping from a height to the ground, or off a carriage in rapid motion. They are usually associated with severe strain, or even dislocation, of the ankle. Twist of the foot in these cases must not be confounded with dislocation of the ankle. In a twist the foot carries with it the lower fragments of the leg-bones, and the malleolar arch in a more or less perfect state. In a dislocation, the foot is thrown out from under this arch. The twist of the foot is almost invariably outwards, with the inner side downwards and the outer edge turned up, and the sole usually remains in this direction, though not always to the extent that Dupuytren states, and the inner malleolus projects under the skin. Most commonly the toes are turned somewhat outwards, and the heel inwards.

Fig. 235.—Displacement of Bones and Foot in Pott's Fracture. (Richard.)

Fractures of the lower ends of the tibia and fibula present four distinct varieties in degree :—

1. The fibula may be broken at its weakest point, two or three inches above the malleolus externus, the deltoid ligament being either stretched or torn.

2. The fibula may be fractured about three inches above the ankle, the tip of the malleolus internus being splintered off as well (Figs. 235, 236). This constitutes the form of injury called **Pott's Fracture**, and is perhaps the most common fracture in this situation. It very frequently becomes compound, the sharp edge of the root of the inner malleolus cutting through the skin as the foot is twisted outwards.

3. The fibula may be fractured about three inches above the ankle, and the lower end of the tibia at the same time may be splintered off in an oblique direction from without, downwards, and inwards (Fig. 237).

4. The internal malleolus may alone be broken off, the fibula remaining sound, but one of the divisions of the external lateral ligament being torn through.

The **Signs** of these fractures vary somewhat according to the bone that is injured. When the fibula alone is broken, there is but slight displacement of the foot, but there are great pain and much swelling, with perhaps indistinct crepitus, and irregularity of outline, at the seat of fracture. When the lower part of the fibula is broken, pain is produced at the fractured part by squeezing

e bones of the leg together at a point distant from the seat of injury. If e tip of the inner malleolus be broken off as well, this may be ascertained by eling the depression above the detached fragment. In these cases the epitus is more distinct, and the displacement of the foot is much more arked, the sole being turned somewhat upwards and outwards, and the tient resting upon its inner side. This peculiar twist of the foot with its iter edge turned up, and the inner side down, is, when present, a most aracteristic sign of Pott's fracture ; but many cases occur in which, although e bones are broken in the same place, the peculiar deformity is absent. In ose cases in which the lower end of the tibia is obliquely splintered, as ell as the fibula broken, there are not only the ordinary signs of fracture, ith eversion of the foot, but the malleoli are widely separated, giving an

Fig. 236.—Pott's Fracture.

Fig. 237.—Fracture of the Lower End of the Tibia and Fibula.

ppearance of increase of breadth to the joint ; crepitus is readily felt, and a epression can be perceived corresponding to the line of fracture.

The **Treatment** of these cases is always troublesome. In consequence of e swelling and inflammation that usually occur, it is often almost impossible make out the exact extent and direction of the fracture. The difficulty of eatment is greatly increased by the small size of, and short leverage afforded y, the fragments ; and so great is it, that in some cases the displacement cannot completely overcome by any amount of skill and patience, but a certain egree of deformity results, leaving a weak and painful joint, the mobility of hich is seriously impaired.

If the fracture results from direct violence, there will be a good deal of welling from ecchymosis and inflammatory exudation ; this will require to be ibdued by the continuous application of cold, and the limb should be laid on splint. If there be but little swelling, and not much displacement of the ot, the treatment may best be conducted by the immediate application of e starched or plaster bandage. When there is too much swelling for this, ut no twist of the foot, perhaps the best treatment is to put the limb up in

lateral leg-splints, with rectangular foot-pieces, and swing it in a cradle. I have found the splint shown in Fig. 238 a very useful appliance in cases of fracture of the bones of the leg, one or both, in their lower third. The apparatus consists of an ordinary leg-splint cut across at the upper part of the lower third, the two pieces being united by a double rack and pinion. The various displacements that are apt to occur with fractures in this situation can thus be counteracted and corrected. It is in cases of fracture of the lower third of the fibula, with displacement outwards, or of both bones low down with tendency to displacement backwards, that this splint will be found most useful. It may be applied to either side of the leg, as seems best to suit

Fig. 238.—Rack-and-Pinion-Leg-Splint applied to correct Displacement of Foot outwards.

the case in question. Whatever apparatus is used, care must be taken to keep the foot at a right angle with the leg. If the toes be allowed to point, it will be found that there is in some cases a tendency for the astragalus to roll forwards, as it were, from under the malleolar arch. In other instances, again, one of the sharp angular fragments connected with the bone may be pressed forwards, and uniting in this position, give rise to permanent deformity. But whatever care be employed, or apparatus applied, it will be found impossible in some cases to replace one of the thin angular fragments, if it become twisted on its axis, and project sharply under the skin.

If the foot be twisted much outwards, as often happens in Pott's fracture,

Fig. 239.—Application of Dupuytren's Splint in Pott's Fracture.

Dupuytren's splint may be applied to the inner side of the limb, to counteract the displacement (Fig. 239). In applying the apparatus, three points require attention: 1. The pad should be folded double at the lower end, and not descend below the upper fragment, so as to form a fulcrum, across which the foot may be drawn to the inner side. 2. The bandage should be applied first to the upper part of the splint. It should not be carried above the knee, but terminate just below the flexure of the joint. 3. The knee should be bent, so as to flex the leg on the thigh, and thus relax the muscles of the calf, which, by drawing up the heel, offer a serious obstacle to the maintenance of the foot in a good position. Much stiffness is always left after union has

taken place, the ankle remaining rigid, weak, and useless for a long time. When this fracture occurs in advanced life the mobility of the ankle-joint is rarely, if ever, regained, and lameness is the almost inevitable result, due partly to adhesions in the sheaths of the tendons, partly to some slight displacement of the articular surfaces. In such cases wrenching, followed by passive motion, douches and frictions may do much to restore mobility.

Dupuytren's Fracture owes its name to the Surgeon who first described it in 1816. The injury resembles Pott's fracture in its mode of production, being caused by forcible eversion of the foot. It differs, however, in the fact that wide separation of the tibia and fibula occurs as the result of rupture of the inferior tibio-fibular ligaments, or separation of that part of the lower end of the tibia to which they are attached. The fibula being fractured about three inches from its lower end, the lower fragment with the foot is forcibly driven outwards, so that the articular surface of the astragalus is completely displaced upwards and outwards from the surface of the tibia. This variety of fracture is extremely rare, and Dupuytren described only two examples. In a specimen in the London Hospital Museum the fracture was compound and due to the fall of a heavy weight on the foot.

The *Treatment* must be carried out on the same lines as that of Pott's fracture.

Fracture of the Internal and External Malleolus occasionally takes place, with great displacement of the foot backwards. It most frequently occurs from catching the heel in running down stairs. The displacement backwards is sometimes not very evident, as the malleoli having gone back with the bones of the tarsus, the appearances are very deceptive, and the patient may thus be left with the toes pointed down and an almost useless foot. It is a good rule in every case of fracture near the ankle to look specially for displacement backwards, even if there appear at first sight to be none, as it is not uncommonly overlooked.

Treatment.—This displacement may be treated by the application of the jointed splint above mentioned (Fig. 238). *Syme's anterior splint* may be used. This is a straight splint, long enough to reach from the head of the tibia to below the foot; its lower extremity is cut out into a deep horseshoe-shaped notch, wide enough to take the instep between the two prongs. It must be padded with a double pad, made of two rolls of cotton-wool in calico; these must lie one on each side of the spine of the tibia to protect it from pressure. The splint is then firmly bandaged to the anterior aspect of the leg, and the foot is drawn forward by bandages passing round the prongs and under the heel, the heel being protected by a thick soft pad.

Compound Fracture into the Ankle-joint is necessarily a dangerous accident. In this injury, the edge of the fractured bone cuts through the integument by apparently a clean and simple wound, but the subjacent areolar tissue is often widely torn, and the deep-seated mischief may be far more extensive than the Surgeon would be led to expect from the external appearances. When the wound is made by the sharp edge of the root of the malleolus, as soon as the foot is replaced and the tension on the skin caused by the eversion is relaxed, the opening no longer corresponds to the seat of fracture, and consequently, if decomposition of the discharges takes place and the joint becomes filled with septic matter, there is no efficient means of drainage, and suppuration, with great tension and deep burrowing

of pus, ensues; the ankle-joint is destroyed and secondary amputation often becomes necessary. The injury, however, is usually recovered from with a good and useful limb when the patient is young and of sound constitution, and the dangers of inflammation and suppuration are guarded against by the establishment of good drainage, by the prevention of decomposition, and by perfect rest. As age advances, however, and the constitution becomes broken, less is to be expected from conservative surgery.

In the *Treatment*, the course to be pursued will depend upon the extent of the injury. If the fracture be not much comminuted, the wound in the soft parts clean cut and but moderate in extent, and the large vessels of the foot uninjured, an attempt should be made to save the limb. The wound and the joint must be carefully cleaned with an efficient antiseptic. If the drainage be insufficient the wound may be enlarged in such a way as to provide free exit for the discharges from behind the malleolus; any splintered fragments must be removed and the wound left open to heal by granulation, some form of antiseptic dressing being applied. The limb must be firmly fixed on a splint; as a rule a lateral splint applied to the side opposite the wound will be found the most convenient. If the wound is on the inner side, as it almost always is, the limb must be flexed and laid on its outer side; should it be on the outer side it may be swung in a Salter's cradle.

If there be great comminution of bone, with dislocation of the foot, and perhaps rupture of the posterior tibial artery, in a person at or beyond the middle period of life, amputation should be practised. In a young subject, even such a serious injury as this may be recovered from, if the Surgeon remove loose fragments and saw off the splintered ends of the bone.

Fig. 240.—Badly set Pott's Fracture, curable by operation.

If much of the fibula should require removal, Stromeyer recommended that the limb should be amputated instead, lest a useless foot, affected with a kind of valgus, be left. But, in children and young subjects, this inconvenience and deformity may be overcome by mechanical means; and the probability of its occurrence would not, in my opinion, justify amputation.

In badly set fractures near the ankle-joint, great deformity with much impairment of use of the foot may result. In these cases the inner malleolus will be found to project greatly, the fibula to be curved inwards above its lower third, so as to form a concavity above the external malleolus, and the foot to be turned somewhat outwards (Fig. 240). I have in two such cases succeeded in removing the deformity to a considerable extent, even after so lengthened a period as two years, by dividing the fibula subcutaneously with a narrow-bladed saw at the seat of greatest concavity, forcibly adducting the foot, and then putting up the fracture in a Dupuytren's splint.

Fractures of the Bones of the Foot almost invariably result from direct violence, and are usually accompanied by bruising and injury of the soft parts; hence much displacement is rare, and, when the fracture is simple,

rest and position alone are necessary. Compound fractures of the tarsal or metatarsal bones, attended with much bruising and laceration, usually require partial removal of the foot, disarticulation at the ankle-joint, or amputation in the lower third of the leg, according to the extent and severity of the injury.

The **Os Calcis** may be broken by direct violence, as when a person jumping from a height alights forcibly on his heel, and thus fractures the bone. In this way the bone may be simply broken across in front of the ligaments without displacement. I have, however, seen both calcanea shattered to pieces, in the case of a lady, who falling from a window on the third storey, alighted on her heels. In some rare cases, by the powerful contraction of the muscles of the calf, the posterior part of the os calcis is torn away from the rest of the bone.

Signs.—When the os calcis is broken through at the posterior part behind the insertion of the lateral ligaments, the detached fragment will be drawn up by the action of the calf muscles. But when the fracture occurs across the body of the bone, no displacement can take place, owing to the lateral and interosseous ligaments keeping the posterior fragment in position.

In the first form of fracture, the pain, swelling, flattening of the heel, and prominence of the malleoli, indicate the nature of the injury, even though crepitus be wanting. In the second variety, the mobility of the fragment, and its projection posteriorly owing to the action of the muscles of the calf, point to the existence of the fracture, which is confirmed by the occurrence of crepitus.

In the *Treatment* of these injuries, keeping the part fixed by means of bandages and splints, with due attention to the relaxation of the muscles attached to the tendo Achillis, by flexing the leg and extending the foot, is all that can be done. In the separation of a small fragment by muscular action, union will probably take place by fibrous tissue, but in other cases by bone.

The **Astragalus** alone is rarely broken. Ten cases of this injury have been collected by Monahan : in nine the fracture occurred from falls from a height on the foot ; in one only from direct violence. I have seen two cases of fracture of the astragalus without implication of the other tarsal bones. In one case it was the result of direct violence ; a cart-wheel passing over the foot occasioned a fracture of the astragalus through its neck. There was no material displacement, but the line of fracture could readily be felt, and crepitus was very distinctly elicited on flexing and extending the foot. No better treatment can be adopted in such a case than the starched or plaster bandage. In the other case the fracture was the result of indirect violence, the patient, a man about 30 years of age, falling from a height of about eight yards, and alighting on his feet. Here the fracture was evidently occasioned by the malleolar arch being forcibly driven downwards on the foot, so that the astragalus was broken transversely just in front of the surface that articulates with the tibia—the line of fracture running obliquely downwards and backwards, so that the whole of the upper and posterior part of the bone was detached. This large fragment was driven outwards and backwards, so as to lie between the fibula and the tendo Achillis, lacerating the skin to the extent of about one inch longitudinally, and projecting through the opening thus made. The foot presented a singular degree of deformity, which is represented in Fig. 241. The outer malleolus projected greatly ; and immediately behind this the displaced fragment could be felt and seen partially protruding through the rent in the skin. The inner

malleolus was depressed; there was a deep hollow below this. The os calcis was apparently turned somewhat towards the inner side of the foot. The sole was arched, the skin much wrinkled, and the great toe forcibly flexed. There was a deep transverse furrow in front of the ankle-joint. Seeing the hopelessness of reduction, or rather the impossibility of maintaining the displaced fragment in position, I enlarged the opening through which it showed itself, and then, seizing it with strong forceps, twisted it out, dividing the ligamentous connexions. The case was then treated as one of compound dislocation of the ankle-joint. About a month after the accident, the patient died of pyæmia; and it was then found that the anterior portion of the astragalus had been splintered into seven fragments, which were retained in place by the pressure of the surrounding parts. No other bone of the tarsus was injured, nor was the malleolar arch fractured. Of this splintering of the anterior fragment, there was no evidence during life; nor was there any reason to suspect it, as there was neither crepitus nor displacement. The extent of the fracture showed the immense force with which the malleolar arch had been driven downwards on the astragalus by the weight of the patient's body.

Fig. 241.—Comminuted Fracture of Astragalus. Displacement backwards.

The only similar case with which I am acquainted is one recorded by Morris. In this the displaced fragment did not occasion a wound of the integument. It was excised owing to the impossibility of reducing it; but caries of the remaining part of the astragalus and other tarsal bones, rendered amputation of the foot necessary.

The other tarsal bones are very rarely fractured, except in crushes or gun-shot injuries of the foot. I have seen the **Scaphoid** fractured in the case of a man who fell down the shaft of a lift at an hotel, about 60 feet deep, receiving fatal injuries to the chest and spine. He appeared to have alighted, in the first instance, on the right foot, the os calcis of which was extensively fractured, and the scaphoid broken across without displacement, the astragalus being uninjured.

In all cases of fracture of the tarsal bones, whether simple or compound, with so much displacement as to render reduction difficult and its maintenance impossible, the best course to be pursued is to cut down upon and remove the displaced fragment.

Fracture of the Metatarsal Bones usually occurs from direct violence, as by the passage of the wheel of a cart or railway carriage over the foot, and is then attended with so much laceration and bruising of the soft parts as not unfrequently to render amputation necessary. I have in one instance known the three outer metatarsal bones broken by a person jumping from a height. But most commonly their elasticity saves them, and the ankle-joint gives way in such an accident. There is but little, if any, displacement in these cases; and unless the soft parts be so damaged as to require amputation, the support of a starched or plaster bandage is usually all the treatment that is necessary.

CHAPTER XXII.

DISLOCATIONS.

Dislocation is the more or less sudden and complete displacement of one of the bony structures of a joint from the other. In the ball and socket joints, as the hip and shoulder, the osseous structures are completely separated from one another, the dislocation then being **Complete.** In the hinge-joints, as the elbow and knee, the osseous surfaces commonly remain partially in contact, though displaced from their normal relations to one another: here the dislocation is **Incomplete.** In most dislocations the integuments covering the displaced bones are put greatly on the stretch; but in some they are ruptured, and then the dislocation is **Compound.** Besides these varieties, Surgeons recognize **Spontaneous** dislocation, in which the displacement does not occur from external violence. In other cases again, the dislocation arises from **Congenital** malformation of the joint, in consequence of which the bones cannot remain in proper apposition; and finally, dislocation may take place as a result of disease in the articulation and surrounding tissues. This is termed **Pathological** dislocation.

It is now customary to describe dislocations of the distal bone or the more movable bone; formerly, dislocation of the proximal bone was often spoken of.

CAUSES.—Dislocation is **Predisposed** to by various conditions, amongst which the nature of the joint appears to exercise most influence; ball and socket joints being more liable to dislocation than any of the other articulations, whilst in some of the synchondroses it never occurs. Krönlein states that 51 per cent. of all dislocations occur at the shoulder-joint, 27 per cent. at the elbow, and 2 per cent. at the hip. These statistics have been obtained from the combined records of the in- and out-patient practice of the hospitals in Berlin, whereas those published by Malgaigne and some others have been derived from in-patient practice only, and are consequently very erroneous.

Dislocations are seldom met with in children, in whom separation of the epiphysis from the shaft more readily takes place. When they do occur it is most frequently at the elbow-joint. Krönlein states that out of 400 dislocations treated in the Berlin hospitals, 22 were met with in this situation in children under ten years of age. I have had under my care a child, just one year old, with dislocation of the head of the femur on the os pubis, occasioned by another older child dragging it along the ground by its leg; Kirby and Madge have both seen dislocations of the femur on the dorsum ilii in children of three and three and a half years old; and Travers has seen the hip dislocated in a boy five years of age. In old people the bones are so brittle, and the ligaments so tough, that violence causes fracture rather than dislocation. Hence it is principally in young and middle-aged subjects that dislocations are met with. This is well illustrated by an analysis of 84 cases of dislocation

of the hip-joint, collected by Hamilton: of these, 15 occurred under 15 years of age, 32 between 15 and 30, 29 between 30 and 45, and 8 between 45 and 85. They are necessarily far more common in men than in women, from the nature of their respective occupations. Thus, according to Hamilton, of 115 dislocations of the hip, only 11 occurred in women.

The articular ends of the bones of the extremities are kept in their proper positions by the arrangement of the osseous and ligamentous structures of the joints, aided by the continuous tension of the muscles; and considerable external violence may be applied to a limb without dislocating it. If, however, the muscles be taken by surprise, or if they have been weakened by previous injury of any kind, the joint becomes predisposed to dislocation, and may be displaced under the influence of very slight causes; especially if it be one in which the articulating surface is shallow and the ligaments are comparatively weak. In this way the same joint may be repeatedly dislocated. Thus I have seen a man whose humerus had been dislocated between forty and fifty times, owing to a weakened state of the deltoid.

The **Direct Causes of Dislocation** are *external violence* and *muscular action*. *External violence* may act directly upon a joint, forcing or twisting the articular ends asunder, as happens when the foot is displaced by a twist of the ankle, or when the thumb is dislocated backwards by a blow. But more commonly the force acts at a distance from the joint that is displaced, and the head of the bone is thrown out of its socket by "the lever-like movement of the shaft," as happens when the head of the humerus is dislocated by a fall on the hand, or when the head of the femur is dislocated.

Muscular action alone may cause the dislocation of a bone, even though the part be previously in a sound state. Thus, the lower jaw has been dislocated by excessive gaping, and the humerus by making a violent muscular effort. If the joint have already been weakened by previous injury or disease, muscular action is especially apt to occasion its displacement. Congenital dislocations have been supposed to arise from irregular muscular contractions in the fœtus, by which the bones are displaced, and the normal development of the joint is interfered with. In dislocations of the ball-and-socket joints, after the head of the bone has been thrown out of its articular cavity, it is often still further displaced by the contraction of the muscles, which continues until they have shortened themselves to their full extent, or until the dislocated bone comes into contact with some osseous prominence that prevents its further displacement.

SIGNS.—The existence of a dislocation is rendered evident by the change in the shape of the joint, and in the relation of the osseous prominences to one another: by the articular end of the displaced bone being felt in a new position; and by an alteration in the length of the limb, and in the direction of its axis. Besides this, there is impaired motion, both active and passive, of the injured articulation, with pain in and around it. It should, however, be borne in mind that fracture may exist with the dislocation; hence the mobility may be increased. In examining a patient for a supposed dislocation the Surgeon should never fail to compare the injured joint with that on the other side of the body.

EFFECTS.—The effects of dislocation on the structure of a joint are always serious. The bones are occasionally fractured as well as displaced, more particularly in hinge-joints; the cartilages may be injured; and the ligaments are

at the same time fracturing the second rib, and separating the first from its cartilage. All the ligamentous structures around the end of the bone were torn through, with the exception of the costo-clavicular ligament, which had preserved its attachments unbroken, and had carried away the cartilage of the first rib in the direction of the displaced clavicle. Dislocation backwards has also occurred as a secondary consequence of curvature of the spine.

The *Signs* are those that usually indicate a dislocation of the sternal end of the clavicle—shortening of the shoulder, and deformity about the upper part of the sternum; but, besides these, a special train of symptoms is occasioned by the pressure of the displaced bone upon the trachea, œsophagus, and vessels of the neck. Difficulty in breathing and swallowing, with congestion of the head giving rise even to a semicomatose state, may be produced to such an extent as to necessitate removal of the end of the bone, as happened in a case of gradual dislocation from deformity of the spine related by Astley Cooper, in which the Surgeon was obliged to saw off the dislocated end. In some cases, the end of the bone is thrown upwards as well as backwards; in others, it takes rather a downward direction.

In the *Treatment* of this dislocation, it is easy to effect the reduction of the bone by making a fulcrum of the fist in the axilla, and then bringing the elbow well to the side, at the same time that an assistant puts his knee between the patient's shoulders and pulls them back; but it is difficult to retain the bone in proper position. To attain this object, the figure-of-8 bandage applied to the points of the shoulders, and crossed over a large pad placed in the middle of the back, will give the most efficient support to the part, the elbow being at the same time well fixed to the side and drawn back.

2. The dislocations of the **Outer End of the Clavicle,** or more correctly, the **dislocations of the Acromion** from the clavicle, are more commonly met with than those just described. The most frequent accident of this description is that in which the bone is thrown **upon the Upper Surface of the Acromion,** or **upon the Anterior Part of the Spine of the Scapula.** It is usually caused by violent falls upon the shoulder, and is not an uncommon accident at football. The prominence formed by the displaced bone upon the upper surface of the acromion, the narrowing of the distance from the mesial line to the point of the shoulder to the extent of from an inch to an inch and a half, the facility of the reduction of the dislocation, and the prominence of the clavicular portion of the trapezius muscle, indicate the nature of the accident (Fig. 245). The *Treatment* is by no means satisfactory. Reduction may easily be effected by raising the shoulder, drawing it backwards, and carrying it outwards by placing a pad or the hand in the axilla and bringing the elbow well to the side. But, notwithstanding the facility of reduction, there is in many cases an unconquerable tendency to the return of the displacement. This is owing partly to the shallowness of the articular surface of the acromion, partly to the tension of the trapezius, by which the acromial end of the bone is drawn upwards, and in a great degree to the mobility of the shoulder. In every movement of the body or neck there will be found to be a tendency to rising upwards of the end of the dislocated bone, and in the majority of cases this will be insurmountable by any mechanical means that can be employed. It is best limited, if not obviated, by a pad and gutta-percha plate laid on the projecting clavicle, and strapped tightly down by a band passing parallel to the arm and under the flexed forearm, this being

retained in position by being attached to a strap passed round the opposite axilla. Even if the displacement continue irremediable, a very useful arm will still be left, though somewhat limited in its upward movements.

The outer end of the clavicle has been dislocated **under the Acromion** by the application of direct violence to the end of the bone. This form of displacement is extremely rare; several instances have, however, been recorded. The diagnosis is easily made and the treatment must be conducted in the same way as that of fractured clavicle.

Fig. 245.—Dislocation of the Clavicle on the Acromion.

The acromial end of the clavicle is said to have been displaced **underneath the Coracoid Process**; but it is possible that the diagnosis was erroneous, as on anatomical grounds such a displacement seems hardly possible.

Simultaneous Dislocation of both ends of the Clavicle is very rare, only four cases having been recorded.

Dislocation of the Scapula.—Under this name has been described a very remarkable kind of displacement of the *Lower Angle and Dorsal Border* of the scapula which is occasionally met with, in consequence of which it projects at a considerable angle from the trunk, giving a winged appearance to the back. This displacement has been attributed to the bone slipping away from under the latissimus dorsi muscle; but it is probable that, in the majority of cases at least, it has really been due to paralysis of the serratus magnus. Paralysis of the muscle is easily recognized: the projection of the scapula is most marked when the arm is put forwards at right angles to the trunk; if both arms are put in this position it will be found that the patient can push the sound arm forwards about two inches further than the other, the scapular movement being wanting on the paralysed side; in some cases there has been difficulty in raising the arm above the head; expansion of the chest is less perfect on the affected side, and if the patient is thin it can be seen that the digitations of the muscle are feebly marked. In a case of this kind recorded by G. V. Poore, in which the paralysis followed chronic neuritis of the brachial plexus, the result of a strain, the patient gradually recovered under electrical treatment. I have seen some benefit derived in such cases from the endermic application of strychnine on a blistered surface, and afterwards from support by means of a properly constructed apparatus.

Dislocations of the Shoulder-joint occur far more frequently than those of any other articulation. The reason of this is to be found in the shallowness of the glenoid cavity, the large size and rounded shape of the head of the humerus, and the weakness of the ligaments; but, above all, in the extent and force of the movements to which the joint is subjected. These displacements indeed would be much more frequent even than they are, were it not for the protection afforded to the joint by the osseous and ligamentous arch formed by the coracoid process and acromion with their ligaments, the great strength of the capsular muscles and their close connection with the joint, and the support given by the tendon of the long head of the biceps; but the principal obstacle to dislocation is the mobility of the scapula, enabling all movements communicated to the hand and arm to react upon that bone.

The **Signs** of dislocation of the shoulder-joint are sufficiently obvious, varying, however, according to the nature of the injury. In all cases there are seven common signs, viz.:—1, flattening of the shoulder; 2, hollow under the acromion; 3, apparent projection of this process, with hollow tension of the deltoid; 4, presence of the head of the bone in an abnormal situation; 5, rigidity; 6, inability to place the hand on the opposite shoulder while the elbow is made to touch the front of the chest; and 7, pain about the shoulder.

The shoulder-joint is susceptible of *four* principal dislocations. Of these, according to Astley Cooper, three are complete, and the fourth partial. I think, however, that on examination it will be found that the so-called *partial* dislocation is in reality a complete one. The directions in which the head of the humerus may be thrown are:—1, *inwards and slightly downwards* beneath the

DISLOCATIONS OF THE HEAD OF THE HUMERUS.

Fig. 246.—Subcoracoid. Fig. 247.—Subclavicular. Fig. 248.—Subspinous. Fig. 249.—Subglenoid.

coracoid process—*Subcoracoid* (Fig. 246); 2, *forwards and inwards* beneath the clavicle—*Subclavicular* (Fig. 247); 3, *backwards and downwards* under the spine of the scapula—*Subspinous* (Fig. 248); 4, *downwards and slightly inwards* under the glenoid cavity—*Subglenoid* (Fig. 249). In three recorded cases the head of the bone has been dislocated *upwards and forwards—Supra-coracoid.*

1. **Subcoracoid Dislocation.**—In the case of *incomplete* dislocation reported by Astley Cooper, the head of the bone was found to be thrown out of the glenoid cavity, lying under the coracoid process upon the anterior part of the neck of the scapula (Fig. 246); the capsular muscles were not torn, but the long head of the biceps had been ruptured. The description given by Astley Cooper, and the illustrative plate in his work on *Dislocations*, appear to point to a form of injury of the shoulder-joint which has been specially described by the French surgeons as a variety of the dislocation downwards; that form of displacement, indeed, which by Boyer has been described as the dislocation "inwards," by Malgaigne as the "subcoracoid" luxation, and by Velpeau as the "subscapular" dislocation—in which the head of the humerus is placed in front of the neck of the scapula, and underneath the subscapular muscle. In this dislocation the head of the bone, instead of being thrown, as in the subglenoid, downwards and slightly inwards, is thrown inwards either directly or slightly downwards as well. Why Astley Cooper described this as a *partial* dislocation, I do not understand; for not only was there rupture of the capsule and of the long tendon of the biceps, but the woodcut at page 401

measured by the effects produced by anæsthetizing the patient. So much of the resistance as is thus overcome is due to muscular contraction. All that which continues after this is due to purely mechanical causes connected with the arrangement of the osseous and ligamentous structures of the joint, or with the injury inflicted on them. The resistance offered by the muscles is of several different kinds, and is dependent on different causes. The influence exercised by the patient's will, and the tonic contraction or passive force exerted by the shortened and displaced muscles, undoubtedly often offer great obstacles to reduction. But more serious than these by far is the reflex or spasmodic action, which the patient is unable to control, and which can be overcome only by force, by faintness, or by the paralysing influence of anæsthetics. The longer the dislocation is left unreduced, the more powerful does the resisting force become; being less at the moment of the accident and immediately afterwards than at any subsequent period. Hence reduction should be attempted as soon as possible after the occurrence of the accident; and, if the patient be seen at once, the bone may sometimes be replaced without much difficulty by the unaided efforts of the Surgeon. Thus Liston reduced a dislocated hip by his own endeavours immediately after the accident occurred. If a few hours have elapsed, the muscular tension becomes so great that special measures must be adopted in order to diminish it; and if some weeks or months have been allowed to pass by, the dislocation may have become irreducible, partly owing to permanent secondary shortening of the muscles, which it is impossible to overcome, but chiefly to the matting together of the surrounding tissues, and the formation of adhesions about the head of the bone. The muscular resistance is greatest when an attempt is made at reduction by forcible traction in the direction of the longitudinal axis of the limb, and parallel to the course of the muscles.

In the reduction of a recent dislocation, advantage may sometimes be taken of the occurrence of faintness, or of the patient's attention being distracted to other matters, when the muscles are, as it were, taken by surprise, and the bone readily slips into its place. Such aids as these, however, cannot be depended upon; and muscular relaxation should be induced by the administration of chloroform or ether. By means of these agents, the muscles of the strongest man may be rendered so perfectly flaccid in a few minutes as to offer no opposition whatever to reduction. In no department of practical surgery has the administration of anæsthetic agents been attended with more advantageous results than in this.

2. The reduction of dislocations is also impeded by the mechanical resistance arising from *the anatomical structure of the joint and its ligaments.* The observations of Bigelow, Busch, and others have proved that this impediment to reduction is of more importance than was formerly supposed. Bigelow has shown by dissection of dislocations of the hip, produced in the dead body, that the characteristic attitude of the limb and the difficulty of reduction are due to the tension of the unruptured parts of the capsule and its accessory bands consequent upon the abnormal position of the head of the bone, and thus it is not until these are relaxed, by placing the limb in the proper position, that reduction can be accomplished. Busch has shown that the same is true of the shoulder-joint, the characteristic position of the chief forms of dislocation being maintained when the whole of the soft parts have been removed except the ligaments. If the ligaments are more extensively torn, the limb falls into

the tendon of the subscapularis torn across, together with the internal portion of the capsular ligament ; the supraspinatus and the long head of the biceps being stretched, but not ruptured.

When the head of the bone is dislocated below the spine of the scapula, it can be felt and seen there, more especially when the arm is rotated. The axis of the limb is altered, being directed upwards and backwards ; the elbow is raised from the side, to which it cannot be approximated, and is carried forwards. There is little or no alteration in the length of the limb, but such as there is is said to be in the direction of lengthening. The accompanying figures, for which I am indebted to Rushton Parker, of Liverpool, show admirably the deformity in this dislocation.

4. In the dislocation **Downwards,** or the **Subglenoid** (Fig. 249), the head of the bone lies in the axilla, resting against the axillary border of the scapula

Fig. 251. — Dislocation of the right Humerus backwards. (Front View).

Fig. 252. — Dislocation of the right Humerus backwards. (Back View).

below the glenoid cavity, and lodged between the subscapular muscle and the long head of the triceps. The tendon of the subscapularis is commonly torn near its insertion into the lesser tuberosity of the humerus, and the capsular ligament is largely lacerated. The supraspinatus may also be torn through, or a portion of the great tuberosity of the humerus detached, and the rest of the capsular muscles put greatly on the stretch. The axillary artery and plexus of nerves are compressed and stretched by the dislocated head of the bone, so that severe pain is commonly experienced in the hand and arm, often accompanied by numbness of the fingers. The compression of the artery is so great that the circulation through the limb may be completely arrested. This I saw well illustrated in a case of subglenoid dislocation complicated with a wound of the forearm, dividing the radial and ulnar arteries. As long as the dislocation remained unreduced, no hæmorrhage took place ; but when the head of the bone was replaced, the injured arteries bled freely.

The head of the bone can usually be readily felt in the axilla, at its anterior and under part ; the arm is lengthened to the extent of about an inch, and the forearm is usually somewhat bent. The elbow is separated from the trunk

cation is often readily reduced; but if it does not yield at once, the direction should be changed, while the traction is kept up, to that which relaxes to the fullest extent the untorn ligaments or bands of the capsule. This will in most cases correspond to the position of the limb at the time of the accident. The head of the bone is thus made to pass along the same track which it has torn for itself in being dislocated, and thus is replaced without the infliction of any additional violence on the surrounding tissues.

The question whether the extending force should be applied to the bone that is actually displaced, or to the further end of the limb, has been much discussed, and appears to have received more attention than it deserves. It is true that, by applying the extending force to the displaced bone itself, the Surgeon has greater command over its movements, with less chance of injury to the intervening bones; whilst, by applying the extending force to the lower part of the extremity, he has the advantage of a longer lever for the reduction of the head of the bone. This lever, however, it must be remembered, is in many cases a broken one; and it cannot be made to act if the bone has to be replaced in the direction of flexion of the joints that exist in its course. For this reason, we find that some dislocations are best reduced by applying traction to the bone itself that is displaced, as in luxations of the femur and of the bones of the forearm; whilst, in other cases, as in the dislocations of the humerus, most advantage is gained by applying the extending force to the end of the limb. But I look upon these points as of comparatively little consequence; believing that, when the patient is not anæsthetized, the muscles of the limb themselves effect the reduction, without the necessity of the Surgeon employing any very powerful lever-like action of the bone; and that, when the patient is paralyzed by chloroform, the bone is in most cases readily replaced by the simple movements impressed directly upon it, or even upon its articular end, by the hands of the Surgeon.


Fig. 242.—Clove-Hitch.

The force required in effecting the reduction of recent dislocations is often very considerable. So great is the resistance offered, that in some cases the dislocated bone has given way. I am acquainted with cases in which the humerus and the neck of the femur have been broken in attempting the reduction of *recent* dislocations. This accident does not always appear to have been the result of any unskilful employment of force, but in some cases seems to have occurred from natural weakness of bone. We know that "spontaneous" fractures take place from muscular action, often of a very slight kind; and we can easily understand that, if a bone that would be liable to such ready fracture happened to be dislocated, it would almost of necessity give way under the influence of the force required to replace it.

Manipulation of the limb—that is, impressing upon it certain movements of extension and flexion, of adduction, abduction, and rotation—is, whenever possible, the best mode of reducing a dislocation. The movements impressed

when it is stretched across the chest. As this is an unusual position for any injury to be received in, this dislocation is proportionately rare. An obstacle to this displacement may also be found in the greater strength of the outer portion of the capsule of the joint, as compared with the inner.

Relative Frequency.—Astley Cooper states that the dislocation "into the axilla" is the most frequent form of accident. This opinion is confirmed by most English Surgeons. But Malgaigne, and more recently Flower, have expressed the opinion that the subcoracoid is the most common form. Flower found that of forty-one specimens in the London museums, thirty-one were undoubtedly *subcoracoid*, and that of fifty recent cases of which he had cognizance, forty-four were of this form. Next in order of frequency comes the *subglenoid*, and then the *subclavicular*, which is rare. I believe the subclavicular to be an exaggerated degree of the subcoracoid; the continuance of the same force which has thrown the head of the bone to the inner side of the coracoid process carrying it upwards and inwards under the clavicle. The displacement of the head of the bone under the spine of the scapula is so rare that Astley Cooper met with only two cases of it.

Diagnosis of Injuries about the Shoulder.—In all cases of injury to the shoulder the patient should be stripped so as to show both shoulders in order that the two sides may be compared. Little can be learnt from the history, as different forms of injury may arise from apparently similar accidents. The attitude of the patient is often characteristic; in all dislocations the elbow is separated from the body and the patient leans towards the injured side, so as to allow the limb to hang perpendicularly in its new axis; in fractures the elbow is close to the side and the arm hangs powerless. In fractured clavicle the patient inclines the head to the injured side and supports the weight of the arm by holding the elbow in the other hand. The power of moving the arm remains to some extent in all dislocations, in impacted fractures of the neck of the humerus, and in fractures of the clavicle between the ligaments; but it is entirely lost in unimpacted fractures of the neck of the humerus and in fractures of the clavicle about the middle, or is accompanied by so much pain that the patient cannot be persuaded to attempt it. Having ascertained this much, the Surgeon should stand behind the patient and place his hands over his shoulders in such a way that the tips of the forefingers rest on the sterno-clavicular articulation and the thumbs on the spines of the scapulæ. By comparing the two sterno-clavicular articulations he will at once recognize any dislocation or fracture of the sternal end of the clavicle. He then moves his fingers outwards along the clavicles until he finds the prominence that always marks the acromio-clavicular articulation on each side. In doing this he will recognize any fracture of the clavicle, and by comparing the acromio-clavicular articulations would detect any dislocation of that joint. The only injury that would escape detection in this way might be the fracture of the clavicle between the coraco-clavicular ligaments. Tenderness would, however, be found which might draw attention to the seat of injury as the fingers passed over it. The fingers are now to be passed round the acromion, carefully comparing it with that on the injured side, by which a fracture of its tip will be detected. At the posterior part of the acromion process near its root is always a small tubercle of bone, which is called the acromial angle. It serves to guide the Surgeon in placing his hands symmetrically on the shoulders, and is also an excellent point from which

partly on the kind of joint that has been dislocated, partly on the particular variety of dislocation that has occurred. Thus, as a general rule, greater freedom of movement and greater utility of limb will be found in old-standing dislocations of ball-and-socket than of hinge joints. But in ball-and-socket joints some dislocations will, if left unreduced, be attended with less evil consequences to the patient than others. Thus, in the *subglenoid* dislocation of the shoulder and the dislocation backwards below the obturator tendon or "*sciatic*" of the hip, the limb will recover itself to a greater extent than in the other forms affecting these joints.

Treatment.—In cases of very old and irremediable unreduced dislocation, much may be done by means of regularly conducted passive movements to increase the mobility of the part, and by means of friction and warm douches to relieve the painful stiffness. In cases not so old, but in which some time has elapsed since the occurrence of the dislocation, two questions always present themselves to the Surgeon :—1. Is it possible to replace the dislocated bone ? 2. Is it desirable or prudent to attempt reduction ?

The possibility of reducing the dislocation will depend partly upon the joint that is dislocated and the nature and extent of the dislocation, but chiefly on the length of time during which the bone has been out of place. Dislocations of the ball-and-socket joints generally can be reduced at a much later period than those of the hinge joints; those of the shoulder can be reduced after a longer lapse of time than those of the hip. The subglenoid dislocation of the shoulder and that of the hip on the dorsum ilii are capable of reduction at a later period than the other luxations of the same joints.

The *latest period* at which reduction is possible has been variously estimated by different Surgeons. Astley Cooper gives three months for the shoulder and eight weeks for the hip. As a general statement, this was no doubt tolerably correct at the time when it was made, although reduction had been effected at later periods than those given by Cooper. Thus Breschet reduced a dislocation of the hip at the 78th day, and Travers at the fifth month. But we may now go far beyond this as the limit of *possible* reduction. Brodhurst has reduced the shoulder on the 175th day ; Smith (U.S.) in one case at the seventh month, in another at ten months and a half ; Sédillot one at a year ; Blackman of Cincinnati, a dislocation of the femur on the dorsum ilii, at six months ; Dupierris of Havana, one at over six months, in a boy, and this without chloroform ; and R. W. Smith, after nine months had elapsed.

The **obstacles to the reduction of old-standing dislocations** are rather pathological than physiological and anatomical as in the case of recent displacements. They are of several distinct kinds :—1. The powerful tonic contraction of the shortened and displaced muscles ; 2. the organic changes that have taken place in the muscles partly from the contraction of the cicatricial tissue formed in the repair of the lacerations which occurred at the time of the injury, and partly from the shortening that has taken place to adapt the muscles to the altered relation of the head of the bone ; 3. adhesions that form between the lacerated capsule and the muscles and the displaced head of the bone ; 4. lastly, as a more remote effect, pathological changes in the articulating surfaces themselves, by which their shape becomes altered and the socket shallowed, contracted, and perhaps ultimately obliterated.

In order to overcome these obstacles a considerable amount of force must be

used, as adhesions and contractions have to be stretched and torn asunder. This is effected by the multiplying pulleys and by manipulation under chloroform. In employing the necessary force, care must be taken to protect the skin from abrasion, or even laceration, by the use of wet flannel bandages or wash-leather. The force exerted by the pulleys must be considerable; but it should be accompanied by free rotatory manipulations and movements of the head of the bone, so as to loosen it from its adhesions; and reduction will usually be effected in this way rather than by forcible traction alone.

Anæsthesia is of inestimable service in these cases; and it is by its means that the Surgeon has been enabled to extend materially the limit of possible reduction. But, in the reduction of old dislocations, anæsthetics do not give exactly the same kind of help as in those of recent date. In a recent dislocation one great obstacle is muscular contraction; and, by relaxing this, anæsthetics enable the Surgeon to replace the bone at once without difficulty. In old dislocations the obstacles, as has just been stated, consist in various pathological changes that have taken place around and in the displaced bones. These conditions cannot be influenced by anæsthesia; and hence, except as a means of producing insensibility to pain and preventing instinctive or voluntary muscular resistance, chloroform will not aid the Surgeon.

It must be borne in mind that the reduction of old dislocations is a work not only of very considerable difficulty, but also of danger. If several months have elapsed, the obstacles arising from the pathological changes already mentioned will usually be so obstinate as to render the reduction impossible without the employment of a dangerous amount of force; and in many cases they will prevent reduction, whatever force be employed.

The **Accidents** that may occur during attempts to reduce old dislocations, whether successful or not, are the following:—1. Laceration of the skin by the constriction and pressure of the bands to which the pulleys are attached. 2. Laceration of muscles: thus the pectoral has been torn through in attempting reduction of old dislocation of the shoulder. 3. The development of inflammation and suppuration around the dislocation, by the violence to which the soft parts have been subjected. From this cause death has several times resulted in attempts at reducing old hip dislocations. 4. Extensive extravasation of blood from the rupture of small vessels in the lacerated soft parts, giving rise to wide-spread ecchymosis. 5. Laceration of one of the larger veins. A patient of Froriep's died from this cause, after rupture of the axillary vein in an attempt to reduce an old dislocation of the shoulder. 6. Laceration of an artery, with subcutaneous arterial extravasation. This serious accident has happened at least twenty times in attempted reduction of old dislocations of the shoulder. The brachial artery has also been torn in attempted reduction of a dislocated elbow. 7. Laceration of neighbouring nerves. Those of the axillary plexus have been torn in attempted reduction of dislocation of the shoulder, and the median in that of the elbow. Flaubert has recorded a case in which the four lower nerves entering into the brachial plexus were torn away from the cord. The patient, a woman 70 years of age, died eighteen days afterwards, with paralysis of both arms and of the leg on the same side as the injury. 8. Fracture of the dislocated bone. This serious accident has usually happened when the Surgeon, after the employment

of extension, has attempted to put in force transverse movements of the bone, or has used the bone as a lever; it has given way, usually high up near the head, at other times in the shaft. It is probable that in most cases this has been predisposed to by the bone having become weakened by want of use. It has occurred several times in the humerus, and at least twelve times in the femur, in attempts at reducing old dislocations of these bones. In most of the recorded cases the bone has readily united, and the condition of the patient has not been materially, if at all, influenced for the worse, except that reduction of the dislocation has necessarily been rendered impossible. 9. Neighbouring bones, such as the ribs and the glenoid cavity, have been fractured in the endeavour to reduce dislocation of the shoulder, and the acetabulum in attempted reduction of a luxated hip. 10. The limb has actually been torn off. This remarkable accident happened to Guérin of Paris, in attempting the reduction, without pulleys but merely by the traction of four assistants, of a dislocation of the shoulder of three months' standing, in a woman 63 years of age, the limb being suddenly torn off at the elbow. The patient died on the twelfth day; and on examination, the bones were found porous, and the muscular and other soft structures pulpy, the limb having evidently lost its natural strength and elasticity.

The occurrence of these various accidents and injuries, in the attempted reduction of old dislocations, cannot always be justly attributed to the employment of an improper amount of force by the Surgeon. The liability to them must rather be looked upon as a necessary accompaniment of attempts at putting back into its place a bone which has been dislocated, and left unreduced for many weeks or months. During this period the bone usually contracts adhesions of a very dense kind to the parts amongst which it lies; and, as it cannot be replaced in its articular cavity until these adhesions have been torn or broken through, it is easy to understand how, in the attempt to do this, neighbouring soft parts, vessels, or nerves may give way, or the bone itself may yield to the force that must be applied to it in order to lift it out of its new bed.

The liability to the occurrence of these accidents should make the Surgeon very cautious how he recommends an attempt to reduce old-standing dislocations. If after a time the new joint have become tolerably mobile and be not painful, it may be better to leave the bone unreduced, rather than expose the patient to great risk, with a slender prospect of eventual success. If the unreduced dislocation give rise to stiffness and pain, much may be done by passive motion, frictions, and douches, to improve the patient's condition.

The **Subcutaneous Section** of muscles, tendons, and bands of adhesions in the neighbourhood of the dislocated joint, was proposed by Dieffenbach as a means of facilitating reduction in old-standing cases; and he has related an instance in which, by these means, a shoulder that had been dislocated for two years was reduced. In many cases in which this plan has been tried, the success has not been commensurate with the expectations founded on it; and in other instances, of which I have seen two or three, the operation has been followed by sloughing and other serious evils, while it has not been attended with any benefit in facilitating reduction. Lister and others have successfully reduced old dislocations of the shoulder by exposing the head of the humerus and dividing the structures which prevented its replacement.

COMPOUND DISLOCATION is one of the most serious injuries to which a limb

can be subjected. Not only is there such extensive laceration of the soft parts that cover and enter into the formation of the joint as to give rise to the most severe forms of traumatic arthritis, but the bones are often fractured, and the main vessels of the limb perhaps greatly stretched or torn.

The *Treatment* of a compound dislocation must be conducted on the same principles that guide the Surgeon in the management of a wounded joint, viz., rest, drainage, and the prevention of decomposition. Owing to the rupture of the ligaments and muscular attachments, there is usually no difficulty in the reduction; but the danger consists in the destructive inflammation that so frequently follows in the joint. This, as was before pointed out, is due chiefly to the accumulation of decomposing discharges in the cavity; but in the case of a compound dislocation, it is aggravated by the severe bruising and laceration of the surrounding structures. Consequently extensive inflammation and suppuration with sloughing may follow the injury. In all cases it is better not to make any attempt to close the wound by suture, as this would only interfere with the drainage, and union by the first intention is practically impossible. Cleaning the wound and dressing it must be conducted on the principles laid down in the chapter on wounds of joints (p. 513). If the joint be a large one, the line of practice will vary according to circumstances other than the mere dislocation. Thus, if it be in the upper extremity, the patient being healthy, and the soft parts not very extensively contused or torn, the bones may be replaced, after the joint has been properly cleaned with carbolic acid lotion (1 in 20), or some other antiseptic solution, and may then be dressed by one of the antiseptic methods already described. Dry cold may be applied over the dressing if possible. The limb must be placed on a splint to ensure rest for about two weeks, after which, if all goes well, passive motion may be commenced with care. Should suppuration take place, passive motion would only ensure the destruction of the joint; the limb must then be firmly fixed on a splint in the hope of obtaining ankylosis. If there be fracture conjoined with the dislocation, resection should be practised, as was successfully done by Hey in several cases of injury of the elbow of this description; but if the soft parts be greatly injured as well, and especially if the blood vessels and nerves of the limb have suffered, amputation must be performed. In the lower extremity, amputation is more frequently necessary; in the knee, almost invariably so. Yet there are exceptions to this rule; thus, White had a case of compound dislocation of the knee-joint in a boy, nine years of age, at the Westminster Hospital, in which he saved the limb by sawing off the condyles of the femur and reducing the bone. In compound dislocations of the ankle and the astragalus, an attempt should generally be made to save the limb, in the way that will be more specially pointed out when we come to treat of these injuries.

After recovery from compound dislocation, the joint will often remain permanently stiffened; hence attention to position during the treatment is essential. In many cases, however, very good motion is ultimately obtained, though the stiffness may continue for some length of time.

COMPLICATIONS.—**Fracture of the Shaft of one of the Long Bones with Dislocation of its Head** considerably increases the difficulty of reduction. In these circumstances, it has been recommended to let the fracture consolidate first, and then to attempt the reduction. But to do this is only to defer and increase the difficulties. At least seven or eight weeks must elapse

before the fracture will be sufficiently firmly united to bear the traction requisite to reduce so old a dislocation; and then there will be a great chance of rupture of the callus, and certainly extreme difficulty in the reduction. It therefore appears to me much better, under all circumstances, to endeavour to reduce the dislocation at once, and afterwards to treat the fracture in the usual way. In reducing a dislocation complicated with fracture of the shaft of the displaced bone, the fracture must first be put up very firmly indeed, with wooden splints completely encasing the limb. The patient must then be put fully under the influence of an anæsthetic, which is essential in these cases; when the muscles are completely relaxed, the reduction may be effected in the usual way. If manipulation fails and extension becomes necessary, the extending means should be applied upon the splints, so that there may be no dragging upon the fracture. In this way I have reduced, without any difficulty, a dislocation of the head of the humerus into the axilla, complicated with comminuted fracture of the shaft of the bone, in a remarkably muscular man; and about the same time I had under my care at the Hospital a case of dislocated elbow, with fracture of the shaft of the humerus, that was reduced with ease in the same way. The difficulty in reduction is necessarily increased by the proximity of the fracture to the dislocated joint, and when the epiphysis is broken off from the shaft and dislocated, the difficulty may be great; but it is not insuperable. Some years since, I assisted H. Smith and Dunn in the reduction of a dislocation of the humerus with fracture of the surgical neck of the bone, the displaced head lying to the inner side of the coracoid process. In this case the patient, a young man who had sustained the injury by a fall in an epileptic fit, was put under chloroform, and when he was fully anæsthetized the displaced head of the bone was easily replaced; the patient recovering with an excellent arm.

When a **Simple Fracture extends into the Articular End of the Bone,** as in some dislocations about the elbow and ankle, there is no material increase in the danger of the case or in the difficulty of its management.

In **Compound Dislocation with Fracture of the Articular Ends,** removal of splinters, and partial resection or amputation will be required, according to the seat and extent of injury.

SPONTANEOUS DISLOCATIONS may occur either suddenly or gradually, and may arise from a variety of causes.

Spontaneous dislocation, if the term can properly be applied to such cases, is often met with as the result of disease of the articulation. In all *destructive inflammation of joints*, as in tuberculous disease or acute arthritis following a wound, the ligaments become softened, the cartilages are destroyed, and the bones entering into the articulation altered in shape by ulceration; in these circumstances the articular surfaces readily become displaced under the influence of slight muscular action. To this class Volkmann has given the name of *Dislocation from Destruction.* In chronic rheumatic arthritis, especially of the smaller joints, and in the joint affections met with in locomotor ataxy, it sometimes happens that the articular surfaces are gradually forced out of their normal relations by the pressure of osseous outgrowths, springing from the bones close to the margin of the cartilages. These are classed by Volkmann as *Dislocations from Deformity.* In another form, which was specially studied and described by Stanley, the affection is due to a paralytic condition of the muscles surrounding the capsule. In these

Paralytic Dislocations, which are most common in the hip and shoulder, the head of the bone slips out without any very marked sign of disease about the joint, and certainly without any previous destruction of it. In another class, to which Volkmann has given the name of *Dislocations from Distension*, the capsule is stretched and weakened by effusion of fluid within it. These are occasionally the result of acute suppuration within the joint, the capsule becoming softened and giving way at its weakest point, and the head of the bone escaping through the aperture. In these circumstances there would be high fever and intense pain, relieved when the capsule gives way. In other cases the fluid that distends the joint is serous in character; these may be acute, but are more commonly chronic. The ligaments then become gradually stretched till they are no longer capable of maintaining the articular surfaces in position. Thus Stanley records a case in which the capsule of the hip was found to be five inches in length, and Hutton another in which the round ligament measured four inches. In such extreme cases as these, the dislocation may take place without rupture of the capsule. The symptoms usually noted have been obscure rheumatic or neuralgic pains, lasting for some time, in the joint previous to dislocation. It may, however, occur suddenly, without any pain, the deformity of the limb first attracting attention. Such dislocations occasionally occur during an attack of acute rheumatism or one of the acute specific fevers. The condition is almost confined to the hip, but other joints may be affected, and sometimes more than one. Thus, some time ago there was a case in University College Hospital, in which both shoulders and hips were dislocated simultaneously.

Lastly, there is a variety known as *Recurrent Dislocations*, in which the joint, having been dislocated and reduced, the muscular and ligamentous structures have become so weakened that ever afterwards the bone slips out of place on the application of slight force, or at will on the patient throwing the muscles of the limb into action. These dislocations are most common in the shoulder. They may be due to incomplete repair of the capsule, or to fracture with displacement of the edge of the glenoid cavity in the shoulder, or acetabulum in the hip. Joessel has described a case in which after death the cause was found to be rupture of the supraspinatus and infraspinatus muscles, which had become retracted under the acromion without forming new adhesions to the head.

The **Treatment** of spontaneous dislocations is not very satisfactory. In many reduction cannot be accomplished; while in others it may be effected readily enough, but the bone cannot be fixed in the joint. In a case of spontaneous dislocation of the hip, without any apparent disease of the joint, occurring in a young woman, I readily effected reduction by the pulleys, three weeks after the occurrence of the displacement. The limb was then fixed with the long splint, and maintained at a proper length for two or three weeks; when, in consequence of a severe bronchitic attack, it became necessary to remove the apparatus, and the displacement speedily returned. Whilst convalescent from this attack, the patient fell and fractured the displaced femur in its upper third, thus rendering it impossible to replace the bone. In another case of spontaneous dislocation of the knee, occurring in the same painless manner, the joint could not be replaced, and permanent deformity was left. After reduction in similar cases, a splint or a starched bandage should be worn for a considerable length of time, so as to give the liga-

ments of the joint a chance of recovery. If there be a rheumatic tendency, it should be removed by suitable treatment; and if there be a paralytic condition of the muscles, electricity and cold douches with friction may advantageously be employed.

CONGENITAL DISLOCATIONS are occasionally met with in the hip, shoulder, wrist, and jaw, and have attracted the attention of Surgeons through the labours of Guérin, Smith, Chelius, Robert, and others. These dislocations are allied in cause and nature to other congenital deformities of the limbs, such as club-foot, &c. In them there is usually found arrested or imperfect development of some portions of the osseous articular apparatus. Whether this is primary, thus causing the displacement of the bones, or consecutive upon disuse, occasioned by spasmodic action of one set of muscles or by paralysis of another, dependent on some irritation in the nervous centres, is scarcely worth inquiring here. In some cases it would appear as if faulty position of the fœtus in utero, or undue violence during birth, may have occasioned the displacement. These dislocations are probably incurable, as there is always congenital defect of structure in the articular ends of the bones, or of the socket into which they are received.

There is a peculiar form of dislocation which I have once, and only once, met with in a child, 12 years of age, otherwise perfectly healthy. It was a dislocation of the head of the radius backwards, in consequence of want of development of the lower third of the ulna. In this case the radius was nearly two inches longer than the ulna. The want of development in the latter bone prevented the proper growth of the forearm; and the radius consequently, after having become slightly curved, was slowly, but completely, dislocated at its humeral end. All the movements of the bone, however, were perfect.

CHAPTER XXIII.

SPECIAL DISLOCATIONS.

DISLOCATIONS OF THE LOWER JAW.

Dislocations of the Lower Jaw are not common accidents. They occur more frequently in women than in men, and have very seldom been met with at either extreme of life; but Nélaton and Malgaigne relate cases occurring in edentulous subjects of 68 and 72 years of age, and Astley Cooper has seen the accident in a child, occasioned by another boy thrusting an apple into its mouth. These dislocations are most frequently occasioned by forcible action of the depressor muscles of the jaw—by opening the mouth too widely, as in laughing and gaping, or in attempting to take too large a bite. Occasionally the accident has resulted from blows or kicks upon the chin when the mouth was open, or from violent strain upon the part in tooth-drawing, or in removing stumps with an elevator. The mechanism of the dislocation is simple. When the mouth is opened, the interarticular fibro-cartilage with the condyle glides forwards on to the articular eminence; if this movement be continued too far, and the external pterygoid muscle contract forcibly, the condyle slips forward over the articular eminence into the zygomatic fossa, the axis of the ramus being directed obliquely backwards, and the dislocation thus being complete. In this way both condyles may be displaced, or only one. Maisonneuve and Otto Weber, by producing dislocation on the dead body, found that the condyle lies in front of the root of the zygoma. The coronoid process rarely reaches the malar bone, but usually lies below it, being completely surrounded by the tendon of the temporal muscle. From original observation, Heath confirms this view of the position of the coronoid process. The interarticular fibro-cartilage is attached to the condyle, and follows its movements. The capsular ligament is stretched, but not ruptured; the external lateral ligament is tense, and passes from behind forward instead of from before backward; the internal lateral and stylo-maxillary ligaments also undergo stretching, which is increased by raising the chin. The temporal muscles are stretched, according to Maisonneuve, or partly torn, according to Weber.

When the dislocation is **Bilateral**, as most frequently happens, the signs are as follows: The incisor teeth of the lower jaw are separated from those of the upper by an interval varying from half an inch to an inch and a half. Deglutition and speech are impaired, the labial consonants not being pronounced; there is dribbling of saliva over the lower lip; the chin is lengthened, and the lower line of teeth advanced about half an inch beyond those of the upper jaw; the cheeks are flattened, and there is a depression in front of the meatus auditorius externus. There is also an oblong prominence in the temporal fossa between the eye and the ear. If the dislocation be left

unreduced, the patient slowly regains some power of movement over the jaw; he gradually approximates the lips, and, after a time, may even be enabled to bring the lines of teeth into apposition, especially posteriorly.

In the **Unilateral** dislocation, the axis of the lower jaw is directed towards the side opposite to that on which the displacement exists; and the general signs are the same, but in a less marked degree, as those which are met with when both sides are dislocated. The hollow in front of the meatus on the injured side is, however, well marked, and serves to point out the seat and nature of the displacement, the diagnosis of which is not always readily made; indeed, R. W. Smith states that he has seen attempts at reduction applied to the uninjured side.

Astley Cooper described a **Subluxation** of the jaw, most frequently met with in young and delicate women, in which, in consequence of the relaxation of the ligaments, the head of the bone appears to slip forwards upon the eminentia articularis, whenever the mouth is opened at all widely, as in gaping, laughing, &c. It may usually be ascertained by telling the patient to put out the tongue. The bone hitches, as it were, and prevents the mouth from being shut at once. Most commonly, the natural efforts of the patient are sufficient to return the head of the bone into the glenoid cavity with a cracking noise or even a loud snap.

The **Reduction** of a dislocated jaw is easily effected; it being necessary

Fig. 243.—Reduction of Dislocated Jaw.

only to push the angle of the bone downwards and backwards, and at the same time to raise the chin; by so doing the attachment of the temporal muscle to the coronoid process acts as a fulcrum, and the condyle is brought slightly downwards so as to be disengaged from the articular eminence, when the internal pterygoid and masseter muscles will at once draw it into its proper position. The reduction is best effected by the Surgeon, standing before the patient, placing his thumbs, well protected by a thick napkin, or a few turns of a narrow bandage, on the molar teeth on each side, and then depressing the angle of the jaw forcibly, at the same time that he raises the chin by means of his fingers spread out and placed underneath it (Fig. 243). The bone is then returned into its place with so forcible a snap that the thumbs may be severely bitten unless care be taken, or they be well protected. When one ... ly is luxated, the efforts at reduction should be applied to the ... only. After the reduction, the four-tailed bandage should be ... in cases of fracture of the jaw; and for several days the patient

must not be allowed to talk, or to eat any solid food, lest the displacement return, which it always has a great tendency to do. Very old dislocations of this bone may be reduced by the process just described. Thus, Stromeyer replaced one after thirty-five, Donovan one after ninety-eight days, and Pollock after four months.

In the cases of *subluxation*, attention should be paid to the state of the general health. Tonics, more particularly iron, should be administered; and good diet, the cold bath, and open air exercise enjoined. If, as frequently happens, there be some tenderness about the temporo-maxillary articulation, a series of small blisters may be applied over it. It is of great importance to prevent the habit of recurrence of the dislocation. This may usually most conveniently be done by letting the patient wear a small silk cap fitted to the chin and attached by four elastic bands on the top of and behind the head, as in the case of a fractured jaw.

Congenital Dislocation of one Condyle of the Lower Jaw is a remarkable and rare condition, for a knowledge of which we are chiefly indebted to R. W. Smith. In this condition there is a singular distortion of countenance. The osseous and muscular structures on the dislocated side are atrophied, and the teeth of the upper jaw project beyond those of the lower, contrary to what occurs in the accidental dislocation; the mouth can be closed, speech is perfect, and there is no dribbling of saliva. Congenital dislocation of both condyles has not yet been observed.

DISLOCATIONS OF THE UPPER LIMB.

DISLOCATIONS OF THE CLAVICLE.—When we look at the flat character of the sterno-clavicular articulation and the very small and shallow surface on the acromion upon which the outer end of the clavicle is received, and reflect on the violence to which the shoulder is frequently subjected, we might at first imagine that dislocations of the clavicle would be among the most frequent forms of injury in this region. But this is very far from being the case. They are, indeed, rarely met with in comparison with fractures of this bone. This is owing to several causes: amongst these are the presence of the interarticular fibro-cartilage in the sterno-clavicular articulation, the shortness and firmness of the ligaments by which the clavicle is attached to the sternum and acromion, and the fact that any force applied to the bone is usually received in a line which corresponds to its axis, thus causing it to be bent or broken rather than luxated. The mobility of the scapula, also, has a special tendency to prevent dislocations of the outer end of the clavicle, the two bones easily moving together.

Dislocations of the clavicle can be occasioned only by violence applied to the shoulder in such a direction as to drive the bone inwards towards the mesial line. Either the sternal or the acromial end of the clavicle may be dislocated, and the simultaneous displacement of both ends has been observed.

1. The **Sternal End of the Clavicle** may be luxated *forwards*, *backwards*, or *upwards*.

In the dislocation **Forwards**, which is the most common form, the end of the bone can be felt in its new position, upon the upper part of the sternum and a litle below the natural level. The point of the shoulder is approximated to the mesial line, and the depressions above and below the clavicle are strongly

The forearm is flexed and very slightly supinated. When the coronoid process is not broken off, it is fixed against the posterior surface of the humerus, the forearm being immovably placed in its new position. In the rare cases in which this process is fractured, there is great mobility about the joint, and crepitation may be felt as the arm is drawn forwards.

Dislocation of both bones **Forwards** without fracture of the olecranon is an extremely rare accident, but a few undoubted cases have been recorded. In this injury the elongation of the forearm, the projection of the condyles of the humerus, the presence of the sigmoid notch in front of the arm, and the depression of the posterior surface of this bone, render the diagnosis sufficiently easy. In one case at University College Hospital, the injury was produced by the patient, a man 20 years of age, slipping on the pavement and falling on his elbow. In this instance the elbow was much bent; it could be brought to a right angle, and straightened considerably. The forearm was three quarters of an inch longer than its fellow. The condyles of the humerus were on a level with the olecranon; the tendon of the triceps was very tight, whilst the sigmoid notch and the head of the radius could be plainly felt on the fore part of the arm. In the case recorded in the *Lancet*, 1872, by Date of Crewkerne, the dislocation was forwards and outwards, so that the head of the radius lay outside the external condyle. At the same time, the epiphysis at the inner condyle was separated. When the olecranon is broken off, there is elongation of the forearm with great mobility, but the detached fragment can be felt behind the humerus.

The **Lateral** dislocation of the bones of the forearm is almost invariably incomplete; either the head of the radius hitching against the trochlea, or the ulna coming into contact with the capitellum. Complete lateral dislocation of the bones of the forearm is excessively rare. Nélaton has given a woodcut of a complete luxation outwards.

The ulna or radius alone may be displaced; and in some cases both bones are dislocated, but in opposite directions.

2. **Ulna.**—The only dislocation to which the ulna alone is subject is that in a direction **Backwards.** This displacement may be uncomplicated, but is more frequently associated with more or less dislocation of the head of the radius. When it occurs, it may be recognized by the projection of the olecranon backwards, and by the head of the radius being felt in its normal situation, or nearly so, during the movements of pronation and supination. In some extremely rare cases the coronoid process is fractured at the same time, causing ready disappearance and recurrence of the dislocation, with crepitus.

3. **Radius.**—The radius alone may be dislocated *forwards*, *backwards*, or *outwards*. The dislocation **Forwards** is by far the most common. In the many instances of it I have seen, it has resulted from a fall on the palm of the hand, by which the lower end of the radius is driven backwards, while the upper end is tilted forwards with the whole force of the leverage of the bone, and in this way, rupturing the orbicular ligament, is thrown against the external condyle. The signs of this displacement are the following: The forearm is slightly flexed, and in a position midway between pronation and supination; any attempt at completing the latter movement occasions great pain, as does also the endeavour to straighten the arm. The elbow can be bent only to a right angle, in consequence of the head of the radius being

suddenly brought up against the lower end of the humerus, against which it strikes with a sudden shock (Figs. 257, 259). On rotating the radius great pain is experienced, and the head of the bone can be felt to roll on the fore part of the humerus, the external condyle of which appears to project unnaturally, with a distinct hollow beneath it where the head of the radius should be. The hand and arm can be fully pronated, but cannot be supinated more than half way. The whole of the outer side of the arm is deformed, being carried somewhat forwards (Fig. 258). The rupture of the orbicular ligament

Fig. 257.—Dislocation of the Radius forwards: Limit of Power of Bending the Arm.

Fig. 258.—Dislocation of the Radius forwards: Deformity of the Outer Side of the Arm when extended.

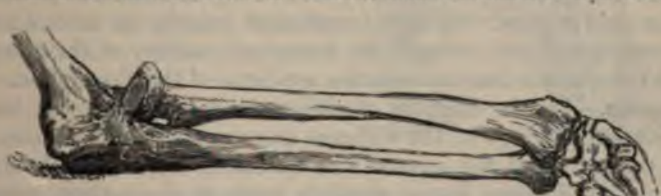


Fig. 259.—Position of the Bones in an old Unreduced Dislocation of the Radius forwards.

in this dislocation makes it very difficult to fix the radius so as to prevent a recurrence of the displacement.

The dislocation of the radius **Backwards** is extremely rare; it may always be recognized by the head of the bone being felt subcutaneously, behind the external condyle; the movements of the elbow, and of the radius especially, being at the same time very limited and painful.

Dislocation of the radius **Outwards** is of more frequent occurrence than the last injury, the head of the bone being thrown on the outer side of the external condyle, where it is felt under the skin, rolling as the hand is moved. The natural motions of the joint are of course greatly interfered with.

Subluxation of the Head of the Radius.—This name has been given to an injury not uncommonly produced in children by the nurse or mother jerking the hand suddenly upwards in an attempt to save the child from falling. The limb is held motionless, with the elbow slightly flexed, and the

elevation of the limb. This mode of reduction was first described by Charles White, of Manchester, in 1770. The patient must be placed upon a low chair or couch, and the arm raised perpendicularly by the side of the head at the same time that gentle traction is made upon it. In many cases so little force is required that no counter-extension is required beyond the weight of the patient's body, or the Surgeon may extend the arm with one hand while he steadies the shoulder with the other placed on the acromion and the outer end of the clavicle. Should more force be necessary, an assistant may steady the shoulder, or the Surgeon may use his foot (Fig. 254). When the bone is felt to slip in, the arm must be brought down to the side, while the head of the bone is held outwards by the hand in the axilla. In this mode of reduction the untorn part of the capsule is relaxed to the greatest

Fig. 255.—Reduction of a Dislocated Shoulder-joint by the Heel in the Axilla.

possible extent, as also is the deltoid, which is one of the most powerful of the muscles concerned in keeping up the displacement. This method is almost painless in most cases, and for this reason should always be tried before resorting to other means.

2. Reduction by the following *manipulation* has been recommended by Kocher in all cases of subcoracoid and subclavicular dislocation :—Seat the patient in a chair, and stand by his side ; then flex his elbow to a right angle and press it inwards as far as possible towards the chest ; then, holding the elbow in one hand, and using the forearm as a lever, rotate gently and steadily outwards till a distinct sense of resistance is felt ; the elbow must now be brought forwards, or in other words the arm must be raised, with a slight inclination inwards, until it is nearly at right angles to the anterior plane of the body, the rotation outwards being maintained ; finally, the hand is placed on the opposite shoulder, by which a movement of rotation inwards is impressed on the humerus. This method, which was the result of the examination of dislocations produced on the dead body, is so devised as to relax the tight bands of the capsule and to make the opening gape. It has, in Kocher's hands, been very successful even with old dislocations : thus, he has success-

fully reduced one at three weeks, two at five weeks, three at seven weeks, four at three months, and two at four months. In one case, an old woman of 70, with an unreduced dislocation eight weeks old, fracture of the arm took place, and reduction became impossible.

3. The reduction of the dislocation *by the heel in the axilla* is a most efficient procedure in ordinary cases. In adopting this plan, the patient is laid on his back upon a low bed or couch, or on the ground; the Surgeon, seating himself on the same side as the dislocated arm, takes the limb by the wrist, and places one foot, covered merely with the stocking, well up into the axilla, so that the heel may press against the lower border of the scapula, and the foot act upon the humerus (Fig. 255). He then draws the limb steadily downwards, and, when it is disengaged to a sufficient extent, brings the hand across the front of the patient, the foot acting as a fulcrum, by which the head of the bone may be reduced by being pushed upwards and outwards. This mode of reduction is very successful in ordinary dislocations into the axilla, and in those under the clavicle. In the latter, however, it will be necessary to draw the arm more obliquely downwards and backwards, and to press the foot somewhat forwards upon the head of the bone, after it has been disengaged by being brought below the coracoid process.

Fig. 256.—Reduction of a Dislocation of the Humerus by the Knee in the Axilla.

4. The reduction *by the knee in the axilla* (Fig. 256) is precisely the same in principle as the last, though not by any means so good a plan, the knee being too large, and not following the movements of the humerus so readily as the foot. In effecting the reduction by this means, the patient is seated on a chair; and the Surgeon, standing by his side and resting one foot upon the chair, places his knee in the patient's axilla. He then seizes the patient's arm above the elbow with one hand, and, steadying the acromion with the other, draws the limb well away from the body and then depresses it across the knee; the head of the bone is thus reduced.

If these simpler methods fail, or if the dislocation be of old standing, it may be necessary to have recourse to the *pulleys* in order to effect reduction. In applying these the scapula must be firmly fixed, the counter-extension being made by passing the patient's arm through a slit in the middle of a jack-towel, which should be fixed firmly to a hook or staple in the wall. The extending force may then be applied immediately above the elbow; traction being made slowly and steadily in the direction of the axis of the limb. The head of the bone should be directed to the glenoid cavity by the pressure of the Surgeon's hands, as soon as it has come on a level with it. In this way dislocations of the humerus of many weeks' or even months' standing have

of the last edition of his work shows clearly that the head of the bone had formed a new articular cavity for itself in the subscapular fossa, being apparently thrown completely out of the glenoid cavity.

There are three specimens in the London museums, two at St. Bartholomew's and one at Guy's Hospital, in which complete dislocation inwards of the shoulder has occurred without rupture of the capsule.

There is here less deformity than in the other luxations, the acromion not forming so distinct a projection (Fig. 250). The alteration in length measured from the acromion to the olecranon is never great, and often none can be detected. It may be either in the direction of shortening or lengthening, but is not enough to be of any diagnostic value. The elbow is generally carried backwards and always slightly away from the side; the head of the bone is placed deeply in the upper and inner part of the axilla, and cannot always be very distinctly felt, owing to its being thickly covered with soft parts, by the coraco-brachialis as well as by the pectorals; rotation of the arm and elevation of the elbow are usually required in order that it may be detected. There may be pain from the pressure of the head of the bone on the nerves or from stretching, and if the vein be pressed on, œdema of the whole limb will occur.

Fig. 250.—Subcoracoid Dislocation of Humerus.

2. In the dislocation **Forwards,** or the **Subclavicular** (Fig. 247), the head of the bone is thrown on the inner side of the coracoid process, lying upon the second and third ribs under the pectoral muscles, and immediately below the clavicle. This dislocation is merely an increased degree of the preceding one, the head of the bone, which at first lies under the coracoid process, being readily drawn inwards, so as to be placed to the inner side of that process under the clavicle. In these cases the capsular muscles are much stretched or torn. In a case recorded by Curling, the infraspinatus and subscapularis muscles were torn away from the tuberosities of the humerus, and the teres minor partially lacerated; the capsule being completely separated from the neck of the bone, which pressed forcibly upon the axillary vessels and nerves. In three cases which I have had an opportunity of dissecting, the great tuberosity was torn away from the head of the bone, with much laceration of the capsule and extensive extravasation, but without rupture of the external rotator muscles in two instances; whilst in the third the supraspinatus, the infraspinatus, and the teres minor, were all torn across near their insertions. In fact, in these cases it appears to be a question of strength between muscle and bone; either the muscles are torn across, or the great tuberosity is torn away, leaving its attached muscles unruptured.

In this dislocation, the head of the humerus can be felt and seen under the pectoral muscles beneath the clavicle; the arm is shortened, the axis of the limb being directed towards the head of the bone, and the elbow is a good deal separated from the side and thrown back.

3. In the dislocation **Backwards,** or the **Subspinous** (Figs. 251, 252), the head of the humerus lies behind the glenoid cavity, and below the spine of the scapula, beneath the infraspinatus and teres minor muscles. Key found

the tendon of the subscapularis torn across, together with the internal portion of the capsular ligament; the supraspinatus and the long head of the biceps being stretched, but not ruptured.

When the head of the bone is dislocated below the spine of the scapula, it can be felt and seen there, more especially when the arm is rotated. The axis of the limb is altered, being directed upwards and backwards; the elbow is raised from the side, to which it cannot be approximated, and is carried forwards. There is little or no alteration in the length of the limb, but such as there is is said to be in the direction of lengthening. The accompanying figures, for which I am indebted to Rushton Parker, of Liverpool, show admirably the deformity in this dislocation.

4. In the dislocation **Downwards**, or the **Subglenoid** (Fig. 249), the head of the bone lies in the axilla, resting against the axillary border of the scapula

Fig. 251.—Dislocation of the right Humerus backwards. (Front View).

Fig. 252.—Dislocation of the right Humerus backwards. (Back View).

below the glenoid cavity, and lodged between the subscapular muscle and the long head of the triceps. The tendon of the subscapularis is commonly torn near its insertion into the lesser tuberosity of the humerus, and the capsular ligament is largely lacerated. The supraspinatus may also be torn through, or a portion of the great tuberosity of the humerus detached, and the rest of the capsular muscles put greatly on the stretch. The axillary artery and plexus of nerves are compressed and stretched by the dislocated head of the bone, so that severe pain is commonly experienced in the hand and arm, often accompanied by numbness of the fingers. The compression of the artery is so great that the circulation through the limb may be completely arrested. This I saw well illustrated in a case of subglenoid dislocation complicated with a wound of the forearm, dividing the radial and ulnar arteries. As long as the dislocation remained unreduced, no hæmorrhage took place; but when the head of the bone was replaced, the injured arteries bled freely.

The head of the bone can usually be readily felt in the axilla, at its anterior and under part; the arm is lengthened to the extent of about an inch, and the forearm is usually somewhat bent. The elbow is separated from the trunk

Fracture of the ribs, by the pressure exercised against the wall of the chest, is supposed to have occurred in some cases.

The *extravasation* of a large quantity of blood into the areolar tissue of the axilla has occasionally occurred, without any evidence of the rupture of one of the main vessels. In these cases the swelling has gradually subsided under ordinary treatment, by rest and evaporating lotions.

More serious by far than this is the *rupture of one of the large blood-vessels* in the axilla. This may happen from the pressure of the Surgeon's heel, as in a case recorded by Hamilton, in which the Surgeon unfortunately forgot to remove his boot ; but more often it has occurred from the humerus having become adherent to the vessel, and lacerating it when torn away, as in Lister's case in which the artery was adherent to a fibrous band passing from the coracoid process to the dislocated head of the bone. The instances of laceration of the axillary artery, and subcutaneous arterial extravasation in the axilla, in the reduction of old dislocations, are so numerous—there being at least twenty on record—as to be a warning to the Surgeon not to employ too much force.

In the great majority of these cases, the arterial extravasation appeared immediately after the employment of forcible and long-continued extension. In four instances, the aneurismal tumour did not appear until after the lapse of some time. In Dupuytren's case a dislocation into the axilla of six weeks' standing was reduced in a woman 60 years of age. Two or three months after this, a tumour appeared in the armpit. This was mistaken for an abscess, and opened ; arterial bleeding ensued, and the patient died on the eighth day, from secondary hæmorrhage. In Nélaton's case the patient, also an old woman, had a subglenoid dislocation which was easily reduced. But an aneurism appeared in the axilla, which, three months after the reduction, compelled that distinguished Surgeon to tie the subclavian. Both these aneurisms were probably circumscribed.

Dupuytren's case was not the only one in which the fatal mistake was committed of opening the aneurism in the axilla ; the same thing was done by Pelletan, who mistook the tumour for an "emphysema" ; the result being of necessity fatal. In cases reported by Verduc, Petit, Platner, and Leudet, the aneurism was allowed to run its course unchecked by efficient surgical treatment, and in every instance proved fatal by the sac giving way, and secondary hæmorrhage ensuing. Charles Bell records a case that occurred at the Newcastle Infirmary, in which the pectoral muscles as well as the artery were torn, and immediate amputation became necessary. In six cases at least the subclavian artery has been ligatured, twice by Gibson, and once by Blackman, Warren, Panas, and Gunther, respectively. Four of them proved fatal by secondary hæmorrhage, and one from suppuration, Warren's being the only case in which recovery took place.

What *Treatment* should be adopted for this distressing accident ? If the aneurism be left to itself, or be treated by inefficient means, it must necessarily prove fatal by its rupture or by sloughing and secondary hæmorrhage. The ligature of the subclavian is not very promising, as a fatal result occurred in five out of the six cases in which it has been tried for diffused aneurism, Nélaton's case having probably been circumscribed. In these circumstances, it appears to me that it would be wiser to apply to these cases the usual principle of treatment that is adopted in cases of diffused axillary aneurism from other

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In the event of the Surgeon being unsuccessful in his attempts at reduction, must endeavour, by means of frictions and passive motion, to restore, as far practicable, the utility of the limb. Forcible attempts to break down lhesion should, however, be avoided lest the axillary vessels be lacerated.

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The **Varieties** of dislocation of the elbow-joint are very numerous, either th bones of the forearm or only one being displaced.

1. **Both Bones.**—The most common dislocation is that in which both nes are thrown *Backwards,* without fracture of the coronoid process. In re cases, however, this process may be broken off. This injury is readily cognized by the projection backwards of the olecranon, carrying with it the ndon of the triceps, on each side of which there is a distinct hollow. The ticular end of the humerus can also be felt projecting in front of the elbow.

The forearm is flexed and very slightly supinated. When the coronoid process is not broken off, it is fixed against the posterior surface of the humerus, the forearm being immovably placed in its new position. In the rare cases in which this process is fractured, there is great mobility about the joint, and crepitation may be felt as the arm is drawn forwards.

Dislocation of both bones **Forwards** without fracture of the olecranon is an extremely rare accident, but a few undoubted cases have been recorded. In this injury the elongation of the forearm, the projection of the condyles of the humerus, the presence of the sigmoid notch in front of the arm, and the depression of the posterior surface of this bone, render the diagnosis sufficiently easy. In one case at University College Hospital, the injury was produced by the patient, a man 20 years of age, slipping on the pavement and falling on his elbow. In this instance the elbow was much bent; it could be brought to a right angle, and straightened considerably. The forearm was three quarters of an inch longer than its fellow. The condyles of the humerus were on a level with the olecranon; the tendon of the triceps was very tight, whilst the sigmoid notch and the head of the radius could be plainly felt on the fore part of the arm. In the case recorded in the *Lancet*, 1872, by Date of Crewkerne, the dislocation was forwards and outwards, so that the head of the radius lay outside the external condyle. At the same time, the epiphysis at the inner condyle was separated. When the olecranon is broken off, there is elongation of the forearm with great mobility, but the detached fragment can be felt behind the humerus.

The **Lateral** dislocation of the bones of the forearm is almost invariably incomplete; either the head of the radius hitching against the trochlea, or the ulna coming into contact with the capitellum. Complete lateral dislocation of the bones of the forearm is excessively rare. Nélaton has given a woodcut of a complete luxation outwards.

The ulna or radius alone may be displaced; and in some cases both bones are dislocated, but in opposite directions.

2. **Ulna.**—The only dislocation to which the ulna alone is subject is that in a direction **Backwards.** This displacement may be uncomplicated, but is more frequently associated with more or less dislocation of the head of the radius. When it occurs, it may be recognized by the projection of the olecranon backwards, and by the head of the radius being felt in its normal situation, or nearly so, during the movements of pronation and supination. In some extremely rare cases the coronoid process is fractured at the same time, causing ready disappearance and recurrence of the dislocation, with crepitus.

3. **Radius.**—The radius alone may be dislocated *forwards*, *backwards*, or *outwards*. The dislocation **Forwards** is by far the most common. In the many instances of it I have seen, it has resulted from a fall on the palm of the hand, by which the lower end of the radius is driven backwards, while the upper end is tilted forwards with the whole force of the leverage of the bone, and in this way, rupturing the orbicular ligament, is thrown against the external condyle. The signs of this displacement are the following: The forearm is slightly flexed, and in a position midway between pronation and supination; any attempt at completing the latter movement occasions great pain, as does also the endeavour to straighten the arm. The elbow can be bent only to a right angle, in consequence of the head of the radius being

suddenly brought up against the lower end of the humerus, against which it strikes with a sudden shock (Figs. 257, 259). On rotating the radius great pain is experienced, and the head of the bone can be felt to roll on the fore part of the humerus, the external condyle of which appears to project unnaturally, with a distinct hollow beneath it where the head of the radius should be. The hand and arm can be fully pronated, but cannot be supinated more than half way. The whole of the outer side of the arm is deformed, being carried somewhat forwards (Fig. 258). The rupture of the orbicular ligament

Fig. 257.—Dislocation of the Radius forwards: Limit of Power of Bending the Arm.

Fig. 258.—Dislocation of the Radius forwards: Deformity of the Outer Side of the Arm when extended.

Fig. 259.—Position of the Bones in an old Unreduced Dislocation of the Radius forwards.

in this dislocation makes it very difficult to fix the radius so as to prevent a recurrence of the displacement.

The dislocation of the radius **Backwards** is extremely rare; it may always be recognized by the head of the bone being felt subcutaneously, behind the external condyle; the movements of the elbow, and of the radius especially, being at the same time very limited and painful.

Dislocation of the radius **Outwards** is of more frequent occurrence than the last injury, the head of the bone being thrown on the outer side of the external condyle, where it is felt under the skin, rolling as the hand is moved. The natural motions of the joint are of course greatly interfered with.

Subluxation of the Head of the Radius.—This name has been given to an injury not uncommonly produced in children by the nurse or mother jerking the hand suddenly upwards in an attempt to save the child from falling. The limb is held motionless, with the elbow slightly flexed, and the

elevation of the limb. This mode of reduction was first described by Charles White, of Manchester, in 1770. The patient must be placed upon a low chair or couch, and the arm raised perpendicularly by the side of the head at the same time that gentle traction is made upon it. In many cases so little force is required that no counter-extension is required beyond the weight of the patient's body, or the Surgeon may extend the arm with one hand while he steadies the shoulder with the other placed on the acromion and the outer end of the clavicle. Should more force be necessary, an assistant may steady the shoulder, or the Surgeon may use his foot (Fig. 254). When the bone is felt to slip in, the arm must be brought down to the side, while the head of the bone is held outwards by the hand in the axilla. In this mode of reduction the untorn part of the capsule is relaxed to the greatest

Fig. 255.—Reduction of a Dislocated Shoulder-joint by the Heel in the Axilla.

possible extent, as also is the deltoid, which is one of the most powerful of the muscles concerned in keeping up the displacement. This method is almost painless in most cases, and for this reason should always be tried before resorting to other means.

2. Reduction by the following *manipulation* has been recommended by Kocher in all cases of subcoracoid and subclavicular dislocation :—Seat the patient in a chair, and stand by his side ; then flex his elbow to a right angle and press it inwards as far as possible towards the chest ; then, holding the elbow in one hand, and using the forearm as a lever, rotate gently and steadily outwards till a distinct sense of resistance is felt ; the elbow must now be brought forwards, or in other words the arm must be raised, with a slight inclination inwards, until it is nearly at right angles to the anterior plane of the body, the rotation outwards being maintained ; finally, the hand is placed on the opposite shoulder, by which a movement of rotation inwards is impressed on the humerus. This method, which was the result of the examination of dislocations produced on the dead body, is so devised as to relax the tight bands of the capsule and to make the opening gape. It has, in Kocher's hands, been very successful even with old dislocations : thus, he has success-

lly reduced one at three weeks, two at five weeks, three at seven weeks, four three months, and two at four months. In one case, an old woman of 70, th an unreduced dislocation eight weeks old, fracture of the arm took place, d reduction became impossible.

3. The reduction of the dislocation *by the heel in the axilla* is a most ficient procedure in ordinary cases. In adopting this plan, the patient is id on his back upon a low bed or couch, or on the ground; the Surgeon, ating himself on the same side as the dislocated arm, takes the limb by the rist, and places one foot, covered merely with the stocking, well up into the illa, so that the heel may press against the lower border of the scapula, and e foot act upon the humerus (Fig. 255). e then draws the limb steadily downards, and, when it is disengaged to a fficient extent, brings the hand across e front of the patient, the foot acting a fulcrum, by which the head of the one may be reduced by being pushed pwards and outwards. This mode of eduction is very successful in ordinary islocations into the axilla, and in those nder the clavicle. In the latter, however, it will be necessary to draw the arm ore obliquely downwards and backards, and to press the foot somewhat rwards upon the head of the bone, after has been disengaged by being brought elow the coracoid process.

Fig. 256.—Reduction of a Dislocation of the Humerus by the Knee in the Axilla.

4. The reduction *by the knee in the xilla* (Fig. 256) is precisely the same in rinciple as the last, though not by any eans so good a plan, the knee being too rge, and not following the movements of he humerus so readily as the foot. In ffecting the reduction by this means, the atient is seated on a chair; and the urgeon, standing by his side and resting one foot upon the chair, places his nee in the patient's axilla. He then seizes the patient's arm above the elbow ith one hand, and, steadying the acromion with the other, draws the limb ell away from the body and then depresses it across the knee; the head of the one is thus reduced.

If these simpler methods fail, or if the dislocation be of old standing, it may be necessary to have recourse to the *pulleys* in order to effect reduction. In pplying these the scapula must be firmly fixed, the counter-extension being made by passing the patient's arm through a slit in the middle of a jack-towel, which should be fixed firmly to a hook or staple in the wall. The extending force may then be applied immediately above the elbow; traction being made slowly and steadily in the direction of the axis of the limb. The head of the bone should be directed to the glenoid cavity by the pressure of the Surgeon's hands, as soon as it has come on a level with it. In this way dislocations of the humerus of many weeks' or even months' standing have

been successfully reduced; but in employing these powerful means, especially under the influence of chloroform, the Surgeon should always bear in mind that, unless care be taken, serious mischief, even laceration of the axillary artery, may result (pp. 651, 652).

After a dislocation of the humerus has been reduced, the limb should be firmly fixed to the side for two weeks. It may then be put in a sling for another fortnight; and, at the end of a month, passive motion, with friction, may be employed. If inflammation occur about the joint, recourse may be had to leeches and evaporating lotions.

After reduction, there is sometimes a tendency for the head of the bone to be drawn upwards and outwards under and against the acromion, owing evidently to the deltoid and coraco-brachialis muscles not being counter-balanced in their actions by those that have been separated from the head of the bone.

Compound Dislocation of the Head of the Humerus is a rare accident. I have, however, seen two cases of it, and in two directions: downwards—*Subglenoid*, and inwards—*Subcoracoid*. In both cases reduction was effected, and the patients did well. In such a case, even though the injury be extensive, it is better not to amputate if the axillary vessels and nerves be uninjured. The limb may be saved by reducing the bone at once; and the wound should be treated according to the rules laid down in the chapter on wounds of joints. If the axillary artery be ruptured, either completely or through its inner and middle coats, obstruction to the arterial circulation of the arm will ensue, and amputation must be performed through the articulation.

Complications.—A *Simple Dislocation of the Head of the Humerus, with Rupture of the Axillary Artery* and the formation of a diffused axillary aneurism, is fortunately rare. The treatment will be discussed when treating of rupture of the artery during attempted reduction of an old dislocation.

A very serious accident, and one apparently difficult to treat, consists in the complication of a *Dislocation of the Humerus with Fracture through the Surgical Neck* of the displaced bone. A case of this kind, to which I was called, is described at page 654.

When the dislocation is complicated with a *Fracture of the Shaft of the Bone*, it should be reduced at once by putting the fracture up very firmly, and then attempting the reduction by one of the usual methods. In the cases to which I have already referred (p. 654), I succeeded without difficulty by means of the heel in the axilla.

Congenital Dislocations of the Shoulder-joint have attracted much attention. R. W. Smith has ascertained, by *post-mortem* examination, the existence of two varieties of this condition—the *Subcoracoid* and *Subacromial*. In these there is wasting of the muscles of the shoulder and arm, the motions of which are extremely limited, whilst those of the scapula are preternaturally great. The condition of the bones is also remarkable. In a case of congenital subacromial luxation of both shoulders there was no trace of a glenoid cavity; but a well-formed socket existed on the outer side of the neck of the scapula, receiving the head of the humerus, which was small and distorted. These dislocations, though existing from birth, usually become more marked as age advances, and are necessarily irremediable, in consequence of the malformation of the bones and the wasting of the muscles.

Old Unreduced Dislocations of the Head of the Humerus are not unfrequently met with. In the majority of these cases there is a considerable amount of pain and immobility about the shoulder at first; but after a time the head of the humerus forms a new bed for itself, and the movements of the arm become freer and less painful, so that eventually a limb, useful for all except the overhead movements, results.

In cases of old dislocation of the head of the humerus, the question as to the advisability of attempting reduction always presents itself to the Surgeon. As a general rule this should always be cautiously attempted under chloroform, in accordance with the principles laid down at p. 650, if only a few weeks have elapsed from the time of the accident, and then it will usually be attended with success. Reduction has been effected in many cases at much later periods than this: by Brodhurst, after twenty-five weeks had elapsed; by Smith (U.S.), after six, seven, eight, nine, and ten months; by Malgaigne, after eight months; by Caron du Pillard, after six months; and by Sédillot, after a year. By the use of the subcutaneous division of muscles, &c., Dieffenbach is said to have succeeded in reducing a dislocation of the shoulder after it had existed two years. In many cases, however, at a much earlier period than these, the Surgeon will fail, notwithstanding the most persevering attempts at reduction.

Of the few cases in which operation has been undertaken for the relief of unreduced dislocations of the shoulder, the most successful are two recorded by Lister, in both of which the dislocation was bilateral. The first case was of more than nine weeks' standing. An incision was made from the coracoid process along the interval between the pectoralis major and deltoid; the tendon of the subscapularis was divided and the soft parts were freely separated from the head and inner part of the neck of the bone with a periosteum elevator; reduction was accomplished by manipulation and the use of pulleys, fibrous bands being divided as they were put on the stretch. The result in both shoulders was excellent. In the second case, a similar operation was performed on one side, whilst on the other side reduction was effected by removing with a chisel the articular portion of the dislocated head of the humerus. With strict antiseptic precautions the Surgeon should not hesitate to adopt this method rather than incur the risk of lacerating the axillary artery, which may be firmly adherent to the head of the bone, by forcible attempts at reduction.

The *Accidents* that have occurred in attempts at reducing old-standing dislocations of the head of the humerus are such as may arise either from the employment of an undue amount of force, from the separation of the head of the humerus from the adhesions which it has contracted in its new situation, or from pathological changes in the limb itself. Among the first are laceration and bruising of the skin, subcutaneous areolar tissue, and muscles, with extravasation of blood; amongst the latter are fracture of the humerus, laceration of the axillary vessels and nerves, and avulsion of the limb.

Fracture of the humerus has occurred in the practice of many Surgeons of eminence. The surgical neck of the bone appears usually to have given way; and the accident has not occurred so much from forcible extension, as in carrying the arm across the chest so as to tilt the head of the bone into its place, when the shaft becomes exposed to fracture by pressure in a transverse direction. Such an accident necessarily prevents all further attempts at reduction.

Fracture of the ribs, by the pressure exercised against the wall of the chest, is supposed to have occurred in some cases.

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3. **Radius.**—The radius alone may be dislocated *forwards*, *backwards*, or *outwards*. The dislocation **Forwards** is by far the most common. In the many instances of it I have seen, it has resulted from a fall on the palm of the hand, by which the lower end of the radius is driven backwards, while the upper end is tilted forwards with the whole force of the leverage of the bone, and in this way, rupturing the orbicular ligament, is thrown against the external condyle. The signs of this displacement are the following: The forearm is slightly flexed, and in a position midway between pronation and supination; any attempt at completing the latter movement occasions great pain, as does also the endeavour to straighten the arm. The elbow can be bent only to a right angle, in consequence of the head of the radius being

suddenly brought up against the lower end of the humerus, against which it strikes with a sudden shock (Figs. 257, 259). On rotating the radius great pain is experienced, and the head of the bone can be felt to roll on the fore part of the humerus, the external condyle of which appears to project unnaturally, with a distinct hollow beneath it where the head of the radius should be. The hand and arm can be fully pronated, but cannot be supinated more than half way. The whole of the outer side of the arm is deformed, being carried somewhat forwards (Fig. 258). The rupture of the orbicular ligament

Fig. 257.—Dislocation of the Radius forwards : Limit of Power of Bending the Arm.

Fig. 258.—Dislocation of the Radius forwards : Deformity of the Outer Side of the Arm when extended.

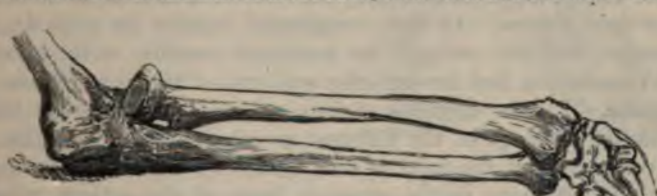

Fig. 259.—Position of the Bones in an old Unreduced Dislocation of the Radius forwards.

in this dislocation makes it very difficult to fix the radius so as to prevent a recurrence of the displacement.

The dislocation of the radius **Backwards** is extremely rare ; it may always be recognized by the head of the bone being felt subcutaneously, behind the external condyle ; the movements of the elbow, and of the radius especially, being at the same time very limited and painful.

Dislocation of the radius **Outwards** is of more frequent occurrence than the last injury, the head of the bone being thrown on the outer side of the external condyle, where it is felt under the skin, rolling as the hand is moved. The natural motions of the joint are of course greatly interfered with.

Subluxation of the Head of the Radius.—This name has been given to an injury not uncommonly produced in children by the nurse or mother jerking the hand suddenly upwards in an attempt to save the child from falling. The limb is held motionless, with the elbow slightly flexed, and the

hand in a position midway between pronation and supination. On examination no displacement of the bony points at the elbow can be detected; complete flexion of the elbow is impossible and supination is arrested at the mid-position. Of the many explanations of these symptoms which have been suggested two may be especially mentioned. Some Surgeons have supposed that an incomplete dislocation of the head of the radius forwards occurs, whilst others believe that the radius is drawn away from the capitellum by the sudden extension applied to the forearm and that the return of the bone is prevented by a folding in of the orbicular ligament. The *Treatment* consists in flexing the elbow and strongly supinating the hand, when a click is felt over the head of the radius and the movements of the limb are restored. The elbow should then be fixed for three or four days.

Congenital Dislocation of the Radius is occasionally met with, the head of the bone being displaced in either of the three directions mentioned above. F. C. Abbott has recorded a remarkable series of seven cases of congenital dislocation forwards, occurring in four generations of one family.

The **Radius** and **Ulna** are sometimes displaced in **Opposite Directions**, the ulna being thrown *backwards*, and the radius *forwards*. This injury, of which I have seen two instances, usually results from heavy falls upon the hand, with a wrench of the limb at the same time, as when a person is thrown out of a carriage and alights upon his hands. The deformity is of course great, but is readily recognized by the combination of the characters of the two forms of displacement, provided an examination be made before the swelling, which rapidly sets in, has come on.

Complications.—Dislocations of the elbow-joint are very frequently complicated with fracture of one or other condyle of the humerus, of the olecranon, and—more rarely, as we have already seen in the displacement of the ulna—of the coronoid process. In these complicated injuries an exact diagnosis is often extremely difficult, owing to the laxity and mobility of the parts, and to the great tumefaction that accompanies accidents of this description.

Diagnosis.—For the diagnosis of these various injuries a good knowledge of the relative bearings of the different osseous points is essential, but an accurate comparison of the injured with the sound limb is equally important. To do this the Surgeon should stand in front of the patient, whose arms should be placed in exactly the same position on each side. The Surgeon then grasps the right elbow with his left hand, and the left with his right, in such a way that his forefinger on each side is on the point of the olecranon, his thumb on the outer condyle, and his middle finger on the inner condyle. The relative position of these three points is thus easily ascertained. If they bear their normal relation to one another the case is not one of dislocation of both bones in any direction, but it may in a young subject be a separation of the lower epiphysis of the humerus (see p. 522). The thumb on each side must then be gradually moved down the ridge formed by the outer condyle, and if the radius is displaced a hollow will be felt immediately beneath it, contrasting clearly with the prominence on the uninjured side. An assistant should then pronate and supinate the hands, by which the head of the radius will easily be recognized in whatever position it may be. Many errors in diagnosis of these injuries arise from not carefully comparing the two sides in this way. It not unfrequently happens, however, that the swelling so obscures the bony points that within a few hours of the injury diagnosis is impossible.

The mode of **Reduction** in dislocations of the elbow-joint varies according as the ulna is displaced or not. When the ulna is dislocated, in whatever direction it may be thrown, and whether the radius be displaced at the same time or not, the great obstacle to reduction is the hitching of the processes of the bone against the articular end of the humerus. If either the olecranon or the coronoid process be fractured, this entanglement cannot take place, and the joint then readily slips into its position, though it is very difficult to maintain it there. The reduction of the displaced ulna, when uncomplicated by fracture, may be effected, as Astley Cooper recommended, by bending the arm over the knee. The patient being seated on a chair, the Surgeon rests one foot upon the seat, and, placing the knee in the bend of the injured elbow, grasps the forearm with both hands (Fig. 260); fixing the arm, he presses the knee firmly against the inner aspect of the forearm, so as to disengage the ulna from the lower end of the humerus, and at the same time he bends or pushes the forearm into proper position, into which, indeed, it has a tendency to return owing to the action of its own muscles, as soon as the opposing osseous surfaces are separated.

Fig. 260.—Dislocation of the Elbow: Reduction.

In a case of backward dislocation of both bones, under the care of W. G. Spencer, of the Westminster Hospital, the protrusion of the end of the humerus through a rent in the anterior ligament rendered reduction without operative interference impossible.

In dislocations of the radius, all that is required is to fix the upper arm, and then, employing extension from the wrist, to straighten the arm well; when, by bending the elbow at right angles, the head of the radius may be pressed into a proper position.

After reduction has been effected, the limb should be put up in an angular splint, the hand being kept semiprone. If the radius have been displaced, a pad may be applied over its head, so as to prevent a return of the displacement, which is very apt to occur when the orbicular ligament is torn. In the case of dislocation of the radius *forwards*, reduction is best maintained by keeping the arm in the flexed position, and thus relaxing the biceps which tends to draw the bone forward when the elbow is extended. The inflammation which usually results must be treated by the application of evaporating lotions. When it has subsided, passive motion may be commenced, and frictions and douches employed, so as to remove the stiffness that is apt to be left about the joint.

In those cases in which the dislocation is complicated with fracture of some part of the articular ends, and in which the diagnosis of the precise nature of the injury, owing to the swelling or other causes, has not been very clearly

made out, the joint should be placed in as good a position as possible, by a process of traction, flexion, and moulding, so as to bring the osseous points into proper bearing with one another, and angular splints must then be applied. At the end of three weeks passive motion may be commenced, lest permanent rigidity, which is very apt to supervene, come on.

Compound Dislocations of the Elbow are always serious injuries, although by the employment of a rigorous antiseptic treatment their gravity may be much lessened. By these means a useful joint may usually be saved, when the soft parts are not too extensively lacerated, without any operative interference. In other cases the Surgeon may have to decide between resection of the articular ends and amputation of the arm. In this the Surgeon will be guided by the considerations stated at p. 594, in reference to compound fracture of this joint. Recovery with a very useful limb has been recorded even after compound dislocation of the elbow, complicated with rupture of the brachial artery.

Old-standing Dislocations of the Elbow are reduced with much difficulty in all cases in which the ulna is completely displaced; this is owing rather to the interlocking of the irregular articular surfaces and to the formation of adhesions in the torn capsule and around the displaced bones, than to muscular contraction. The tendon of the triceps, and even that of the biceps, have been divided in order to facilitate reduction, but in those cases in which I have done this or seen it done, no good has resulted. As a general rule, I believe that it will be found extremely difficult, even under anæsthesia and with the aid of the pulleys, to reduce an ulna that has been completely dislocated for more than a month, although successful cases of many months' standing have been recorded. When the ulna is only partially dislocated, even though the radius be completely displaced, reduction may be effected without much difficulty at a much later period—it is said, as late as two years after the accident; here, however, the difficulty is not to effect but to maintain the reduction, as the bone has a constant tendency to slip forwards and outwards. Provided a dislocated elbow can be so far reduced as to allow the forearm to be bent at a right angle, a useful arm will be left.

Dislocation of the Lower End of the Radius, or, as it is sometimes termed, **Dislocation of the Lower End of the Ulna,** may take place either in a forward or a backward direction. The signs of the displacement are very evident, the lower end of the ulna forming a sharp projection under the skin. This dislocation has also been met with occasionally as a complication of fracture of the radius either at its lower end or in the shaft. In a case recorded by Godlee the radius was fractured very obliquely at the junction of the lower and middle thirds. The lower end of the ulna was torn away from its attachments and was projecting beneath the skin on the front of the carpus, the flexor carpi ulnaris having slipped completely behind it. The injury was caused by a violent fall backwards, the patient's hands being put out behind him to save himself. It was found impossible to replace the limb in proper position, even under an anæsthetic, and the lower end of the displaced ulna, including the lesser sigmoid cavity, was removed through an incision made over it. After this the fractured radius and the displaced hand were easily restored to their normal position. The patient recovered with a most useful hand. E. M. Moore, of Rochester, New York, has removed the lower end of the ulna

in five cases somewhat similar to the above. In every case recovery took place with practically no impairment of function.

Dislocations of the Wrist are of such rare occurrence that their existence has been denied by Surgeons of great experience. Although there can be no doubt that fractures at the lower end of the radius, more especially when impacted, have often been mistaken for these displacements, yet there can be no question that they do occasionally occur, any doubt upon this point having been cleared up by the dissection of cases by Marjolin and Voillemier. The observations of these Surgeons, together with those previously made by Astley Cooper, tend to show that dislocation of the **Hand and Carpus** from the radius may take place either *backwards* or *forwards*.

These accidents are occasioned either by falls on the palm, or by the hand being forcibly bent forwards. In falls on the palm the hand may be thrown forwards under the bones of the forearm, lying on their palmar aspect. In forcible bending of the hand forwards there may be displacement of it and the carpus backwards on the dorsal aspect of the radius and ulna.

In the **Dislocation of the Hand and Carpus Backwards**—the **Dorsal** displacement—there will be shortening of the limb below the elbow, with a large dorsal prominence occasioned by the carpus overlapping the lower end of the radius, which bone will be felt and seen as a projection on the palmar side. In the other variety of radio-carpal dislocation, the **Hand and Carpus are thrown Forwards** under the radius and ulna on their **Palmar** aspect. This dislocation is illustrated in the accompanying figure taken from a cast sent to me by Cadge of Norwich (Fig. 261). In it the projection of the styloid process of the ulna and the lower end of the radius form a concave line on the dorsal aspect, overlapping the carpus, which lies on the palmar side of the radius.

Fig. 261.—Dislocation of the Hand and Carpus forwards.

The *Diagnosis* of these injuries has to be made from sprains of the wrist, from simple and from impacted fractures of the radius. The great and prominent deformity will at once enable the Surgeon to distinguish a dislocation from a simple sprain. From simple fracture of the lower end of the radius, the peculiar deformity (see p. 599), and the absence of crepitus, will afford ready means of diagnosis. It is from the impacted fracture of the lower end of the radius that it is most difficult to distinguish a dislocation. In the dislocation, however, the general laxity of the wrist-joint, the greater readiness with which the deformity is removed, the peculiar and abrupt swelling, and the absence of obliquity of the hand towards the radial side, will enable the Surgeon to distinguish the true nature of the injury.

In the *Treatment* of these cases, reduction is readily effected, and must be maintained by the application of antero-posterior splints of sufficient length to take in the hand.

Compound Dislocation of the Wrist, without fracture of the bones of

the forearm, is a rare accident. In one such injury under my care, inflicted by machinery, the hand was thrown forwards, the radius projecting backwards, and the soft structures on the palmar aspect of the joint were so extensively torn as to necessitate amputation. The *Treatment* of such a case will depend on the amount of injury done to the soft parts. If these be not very extensively injured, an attempt may be made to save the limb; but if they be widely torn through, the arteries and nerves lacerated, and the tendons hanging out, amputation will be required.

Congenital Dislocation of the Wrist may take place either forwards or backwards. The limb is in either case greatly deformed. The bones are shortened and altered in shape, more especially the lower end of the radius. The muscles are also shortened, the extensor tendons forming a sharp angle as they pass over the carpus.

Dislocations of Single Bones of the Carpus are by no means frequent. The bone that is most commonly displaced is the **Os Magnum.** This accident is usually caused by falls, in which the hand is violently bent forwards, in consequence of which this bone starts out from its articulations, projecting as a round hard prominence on the back of the wrist opposite to the metacarpal bone of the middle finger. It may readily be reduced by being pressed upon while at the same time the hand is extended. There is, however, a great tendency for the bone to slip out again, leaving considerable weakness of the joint; so much so, that in two cases recorded by Astley Cooper, the patients found it necessary to wear artificial supports.

The **Pisiform Bone** is occasionally dislocated upwards. In a case under my care, it was displaced by an effort to lift a heavy weight, and drawn up the arm to a distance of nearly an inch by the flexor carpi ulnaris.

A case some time ago occurred to me, at the Hospital, in which the **Semilunar Bone** was dislocated. The patient had fallen from a height, injuring his spine, and doubling his right hand under him. On examining the wrist, a small hard projection was felt on its dorsal aspect; this readily disappeared on extending the hand and employing firm pressure, but started up again as soon as the wrist was forcibly flexed. It was evident that the bone belonged to the first row of the carpus; and from its size, position and shape, there could be little doubt that it was the semilunar bone. Taaffe, of Brighton, has related a case in which the semilunar bone was dislocated anteriorly, so that it projected upwards and forwards between the radius and ulnar.

Dislocations of the Metacarpal Bones.—The **Metacarpal Bones** may very rarely be dislocated from the carpus. This accident happens usually to a single metacarpal bone; which, in consequence of some extreme degree of violence, is forced out of its bed and thrown backwards on the carpus. Most frequently, it is the result of injury and shattering of the hand by gun-barrel or powder-flask explosions; and in such cases the metacarpal bone of the **Thumb** commonly suffers, the dislocation being compound, and complicated with extensive laceration of the palm, and possibly with fracture of the bones. Except in such cases dislocation of the metacarpal bone of the thumb is rare, though the articulation between this bone and the trapezium appears at first sight not to be of a character to resist great external violence. This is probably owing in a large measure to the powerful muscles by which the bone is supported in all cases in which the force is applied upon its palmar aspect, as it most frequently is, as well as to the little leverage afforded

by so short a bone. Luxation of the metacarpal bone of the thumb has, however, been observed to take place *forwards* as well as *backwards*, the latter being the more common. The *Reduction* is in general easy, extension being made from the thumb by means of a piece of tape applied round the first phalanx.

Next to the metacarpal bone of the thumb, those of the **Index** and **Middle Fingers** are most liable to dislocation backwards: in some cases complete, in others incomplete. I know of no recorded case in which *all* the metacarpal bones have been dislocated from the carpus. The annexed engraving (Fig. 262) from a cast in University College Museum, was taken from a patient in the Hospital, in whom I believe that this accident must have occurred; the hand being thrown forwards and shortened, and the carpal bones forming a

Fig. 262.—Dislocation of the Metacarpus, forwards, from the Carpus.

Fig. 263.—Dislocation, backwards, of the Proximal Phalanx of the Thumb.

rounded and *convex* prominence on the dorsum of the metacarpus. The convex appearance of this corresponds with the outline of the carpal bones, and differs so very remarkably from the concave aspect of the lower end of the radius and ulna, as seen in the radio-carpal dislocation (Fig. 261), that I think there can be little doubt as to the nature of the injury.

The *Treatment* of such cases will be the same as that for ordinary dislocations of the carpal bones; splints of sufficient length to take in the hand being applied, after reduction, in order to maintain the parts in position.

Dislocations of the Metacarpo-Phalangeal Articulations are by no means of common occurrence. They are usually produced by falls on the hand, and are met with at all ages; most commonly in the young adult, but sometimes at an earlier age. I have seen this accident in a child four years old. Most frequently the **Proximal Phalanx of the Thumb** is the bone that is dislocated, being thrown *backwards* on the metacarpal bone (Fig. 263) in such a way that the articular surface of the phalanx rests upon the back of the metacarpal bone immediately above its head (Fig. 264). The signs of the accident are sufficiently evident. In the normal state of the hand, the metacarpo-

phalangeal articulation of the thumb is convex backwards; in this dislocation it becomes convex towards the palmar aspect and angularly concave behind. The head of the metacarpal bone can be felt and seen projecting on the palmar aspect of the thumb. The proximal phalanx stands up as it were upon the back of this bone, but the articular surface of the phalanx cannot be felt, owing to its being in contact with the posterior part of the metacarpal bone just above its neck. The phalangeal articulation is always semiflexed. This dislocation of the proximal phalanx of the thumb has, owing to the difficulty of its reduction, attracted more attention from Surgeons than it would at first sight appear to deserve. In some cases the dislocation has proved irreducible, notwithstanding the employment of as much force as it was safe to use, and the Surgeon has been obliged to have recourse to operative interference in order to replace the head of the bone. The obstacle to the reduction of this small bone has been attributed to different causes. Thus, Hey supposed that it was owing to the constriction of the neck of the bone between the lateral ligaments of the joint, and Dupuytren entertained a similar opinion. The folding in of the anterior ligament of the joint, and the interposition of a sesamoid bone between the articulating surfaces, have also been regarded as giving rise to this peculiar difficulty in reduction. The more probable explanation, however, appears to be that the narrow neck of the metacarpal bone becomes constricted by the two tendinous attachments of the short flexor of the thumb, which must be carried back over its broader head, together with the displaced phalanx; the head of the metacarpal bone being grasped between the tendons and the torn capsule of the joint, like a stud between the sides of a button-hole. The observations of Vidal, Malgaigne, and Ballingall point to this as the cause of the great difficulty in reduction that is often met with.

Fig. 264.—Dislocation of the Proximal Phalanx of the Thumb.

Reduction.—Although, as has been said, great difficulty in reduction is often met with, it would be a great error to suppose that it always exists. On the contrary, very many of these dislocations are most readily reduced by simple traction and manipulation. Should any difficulty be experienced, the following plan will usually succeed. The hand and metacarpal bone being fixed by an assistant, the Surgeon bends back the thumb, so as to bring the phalanx to a right angle with the metacarpal bone on which it is displaced. He now employs traction in the axis of the displaced portion of the thumb, keeping the metacarpal bone well pressed down into the palm. Having thus unlocked the phalangeal articular surface from the back of that bone, he draws it well forwards, and, when it is opposite the head of the metacarpal bone, bends it down into the palm. In this way I have reduced a dislocation of the phalanx backwards between five and six weeks after its occurrence. Simple traction in the straight direction, however forcible, and even when aided by the pulleys, will do little, if any, good in the reduction of this dislocation, as the only effect is to draw the slit in the capsule and the two

heads of the short flexor more tightly round the neck of the bone. Very severe extension has been employed without any effect; and there is a tradition in the surgical profession in London of a thumb having been dragged off in the attempt to reduce this dislocation by pulleys. If the Surgeon fail in reducing the displaced phalanx by manipulation under chloroform, as above described, or by traction, the dislocation should not be left without a further effort to replace the bone; and this may usually be done readily enough by the subcutaneous section of the resisting structures. The Surgeon must bear in mind that the obstacle to reduction is purely mechanical; that muscular contraction has nothing to do with it; and that it is quite as great when the patient is anæsthetized as when he is not. He must therefore enlarge the slit in the capsule, and divide the tense bands formed on each side by the tendinous attachments of the short flexor. This operation is best done by passing a tenotome through the skin in front of the joint, and cutting first on one side, then on the other. The chief resistance will be found on the ulnar side of the thumb, where the tendinous insertion of the adductor pollicis joins that of the short flexor. After these structures have been cut through,

Fig. 265.—Reduction of Dislocation of Thumb.

the phalanx can be placed, and the thumb should be put up securely between splints.

When reduction has been effected, care must be taken to prevent recurrence of the displacement. This is best done by keeping the thumb bent into the palm, and retaining it there by means of a gutta-percha cap moulded over it and bandaged down. If the dislocation be left unreduced, the thumb will to a great extent become useful, but necessarily shortened, and incapable of much flexion.

In *Compound Dislocation* of this joint, the bone may usually be readily replaced, but in some cases it has been found necessary to remove the head of the metacarpal bone.

Dislocations between the Phalanges are usually partial or incomplete, and most commonly consist of a twist of the second upon the proximal phalanx.

Complete dislocation of the ungual phalanx, though very rare, is possible. I have seen it in the thumb when, by a fall upon its end, the ungual phalanx has been thrown on to the back of the proximal one, the head of which projected on the palmar aspect. I have also known the ungual phalanx of the little finger dislocated backwards in an attempt to catch a cricket-ball.

Partial dislocation of the middle phalanx, which is a very common accident,

is readily recognized by the deformity it causes (Fig. 266), and is easily reduced by pressure and traction in proper directions. A very convenient mode of applying traction is by means of the toy called an "Indian puzzle" which grasps the finger more tightly the more it is pulled upon; or the apparatus represented in Fig. 265 may be used. The finger will continue to be stiff and comparatively useless for some length of time, the joint being swollen and tender; the patient can generally bend it, but cannot extend it fully or bear any traction upon it. This condition is especially apt to be troublesome and chronic if the patient be gouty, or if his general health be otherwise deranged, and it requires rest and local counter-irritation, with appropriate constitutional treatment. In *Compound Dislocation* of the phalanges, the bone should be replaced, the finger supported by a gutta-percha splint, and the wound dressed antiseptically. In some cases it is necessary to remove the projecting end of bone before this can conveniently be done; ankylosis then results, a sufficiently useful finger being left.

Fig. 266.—Partial Dislocation of the Middle Phalanx of the Middle Finger.

DISLOCATIONS OF THE LOWER LIMB.

DISLOCATIONS OF THE PELVIS.—It occasionally happens that, in consequence of severe blows upon or compression of the pelvis, the **Symphysis of the Pubic Bones,** or more frequently the **Sacro-iliac Articulation,** is displaced. Here the nature of the injury is indicated by the deformity that results; and the same treatment is required as in fracture of the pelvis, with which these accidents are commonly associated.

The **Coccyx** is sometimes violently bent, and almost dislocated *forwards*, by falls; or it may be forcibly bent *backwards* during violent parturient efforts. These accidents are apt to be followed by that painful neuralgic affection **Coccydynia,** described at p. 607.

DISLOCATIONS OF THE FEMUR.—Notwithstanding the great depth of the acetabulum, the complete manner in which the head of the thigh-bone is received into its cavity, the firmness of the capsular ligament, and the great strength of the muscles which surround and support the joint, dislocations of the hip are more frequently met with than those of many other joints that appear less perfectly supported. This is doubtless in a great measure owing to the action, on the head of the femur, of the great length of leverage of the thigh-bone itself when external violence is applied to the knee, and of the whole of the lower extremity when the violence is applied to the foot. Dislocation of the hip-joint occurs chiefly in young or middle-aged adults. In very old people, fracture of the neck of the femur will commonly be produced by the same violence that would have displaced the head of the bone at an earlier age. In children dislocation is rare, as the shaft generally gives way. Yet it does happen even at a very early age. Two cases have occurred in my practice: in one the bone was dislocated on the pubic bone, in a child a year and a half old; in the other on the dorsum ilii, in a boy of six.

The different forms of dislocation of the femur were described with great ess and precision by Astley Cooper, according to whom the head is most

ommonly thrown **upwards and somewhat backwards**, so as to lodge on he slightly concave surface between the acetabulum and the crista ilii, resting n the gluteus minimus, and having the trochanter turned forwards (Fig. 267); r the head may be thrown **downwards** into the foramen ovale, lying upon he obturator externus muscle (Fig. 269); or **forwards and upwards** upon he horizontal branch of the pubic bone under the psoas and iliacus muscles, o the outer side of the femoral vessels (Fig. 270); lastly he described a ariety in which the head of the bone was supposed to be thrown **backwards**

DISLOCATIONS OF THE HEAD OF THE THIGH BONE, ACCORDING TO ASTLEY COOPER'S CLASSIFICATION.

ig. 267.—Upwards and somewhat Backwards, on Dorsum Ilii. Fig. 268.—Backwards towards Sciatic Notch. Fig. 269.—Downwards into Foramen Ovale. Fig. 270.—Forwards and Upwards on the Pubic Bone.

nto the great sciatic notch and to rest upon the pyriformis (Fig. 268). It as since been shown, however, that the peculiar features of this form are due ot to the head of the bone sinking into the notch, but to the relation of the emur to the obturator internus muscle.

The classification originally given by Astley Cooper has been slightly odified in accordance with the more accurate knowledge we now possess. t has been shown by experiments on the dead body that the most important tructure in the mechanism of dislocation of the hip is the **ilio-femoral liga-**

ment. Gunn of Chicago, Busch, Von Pitha, and, more recently and fully, Bigelow, have insisted on an exact knowledge of this important ligament as constituting the basis of a correct understanding, not only of the mechanism of the various forms of dislocation of the hip, but also of the proper methods to be adopted for their reduction. Bigelow, to whom we are especially indebted for a most lucid exposition of the subject, has shown that the four commonly described dislocations of the hip could be demonstrated in the dead body after the whole of the muscular and ligamentous structures round the joint had been divided except the ilio-femoral ligament and the obturator internus muscle, which suffice to direct the limb into the position peculiar to each dislocation and to fix it there, the muscle being concerned only in the production of the dislocation described by Astley Cooper as "into the sciatic notch." The importance of the obturator in this form of dislocation had previously been pointed out by Malgaigne, but his observations seem to have been singularly overlooked. The ilio-femoral ligament is of great strength. Bigelow has found its breaking strain in the dead body to range from 250 to 750 pounds. It is single above where it is attached to the anterior inferior spine of the ilium and divides below into two strong bands, one inserted into the upper and the other into the lower end of the anterior intertrochanteric line, from which fact Bigelow gives it the name of the Y-ligament. The **obturator internus muscle** is also, as pointed out by Bigelow, a structure of great strength, owing to the intermixture of tendinous fibres with its muscular substance. In consequence of this arrangement it becomes practically an accessory ligament to the joint.

The observations of Bigelow have shown that whenever one or both of the branches of the ilio-femoral ligament remain untorn the head of the bone falls into certain definite positions giving rise to characteristic signs; when the ligament is completely ruptured the position assumed by the bone is uncertain, being due chiefly to accidental circumstances. He, therefore, divides dislocation into **Regular**, in which one or both branches of the ilio-femoral ligament remain untorn; and **Irregular**, in which the whole ligament is ruptured.

For convenience of description, and with a view to practical utility, the regular dislocations may be divided into three chief groups, to which must be added certain exceptional forms which are so rare as only to require mention.

1. **Dorsal Dislocations**, or **Dislocations Backwards and Upwards.**—Of these there are two varieties: *a*, when the head of the bone passes above the obturator internus (dislocation on to the dorsum ilii); *b*, when the head passes below that muscle (dislocation into the sciatic notch of Astley Cooper) (Figs. 267, 268).

2. **Thyroid Dislocations**, or **Dislocations Downwards.**—These dislocations present four varieties, of which one only is common—obliquely inwards and downwards on the thyroid foramen (Fig. 269). In addition to this, there are three exceptional forms: *a*, inwards and downwards as far as the perinæum; *b*, vertically downwards below the acetabulum; *c*, outwards and downwards as far as the tuberosity of the ischium.

3. **Dislocations Upwards**, or **Pubic Dislocations.**—Of this form there are two varieties: *a*, when the head of the femur is displaced on to the pubic bone (Fig. 270); *b*, when it lies beneath the anterior inferior spine of the ilium, or the *subspinous dislocation.*

The exceptional forms of dislocation are the following:—

4. The **Anterior Oblique,** in which the head of the bone lies behind the anterior inferior iliac spine.

5. The **Supraspinous**, in which the head of the bone lies above the anterior inferior iliac spine, between it and the superior spine.

6. The **Everted Dorsal Dislocation,** in which the head of the bone lies on the anterior part of the dorsum, behind the anterior inferior iliac spine. In the two last forms the outer branch of the ilio-femoral ligament is ruptured.

The **Mechanism of the Production** of these various dislocations has been much discussed. It is generally recognised that in the thyroid and pubic dislocations the limb is abducted at the time of the injury, and that the head of the bone leaves the capsule in a downward direction, passing through the thinnest part of the capsule, the position it afterwards assumes being due to the direction of the force applied to the abducted limb. Astley Cooper believed that in the dorsal dislocation the limb at the time of the accident is adducted and flexed, and that the head of the bone leaves the acetabulum in a direction directly backwards. Henry Morris, who has investigated this subject both by experiment and by observation of specimens, has come to the conclusion that in all dislocations the head of the bone leaves the capsule in a downward direction, while the limb is *abducted.* He is of opinion that with few exceptions all dislocations are primarily the same, that is to say, downwards, the subsequent position of the bone being determined by the degree of flexion and rotation to which the limb is exposed. Thus the posterior dislocation results from flexion and rotation inwards accompanying the abduction, and the anterior or pubic from rotation outwards and extension accompanying the abduction, while the downward dislocations result from forced abduction alone. That this explanation is true of the great majority of dislocations is highly probable, but there are recorded cases to show that a dorsal dislocation may occur in the way described by Astley Cooper, directly backwards during flexion and adduction.

With regard to the **Relative Frequency** of the various forms of dislocation, Astley Cooper says that of 20 cases of dislocation of the hip, 12 will, on the average, be on the dorsum ilii (above the tendon of the obturator internus of Bigelow), 5 on the sciatic notch (below the tendon of the obturator internus), 2 on the thyroid foramen, and 1 on the pubic bone. Hamilton states that, excluding anomalous cases, of 104 dislocations which he has collected, 55 were on the dorsum ilii, 28 into the sciatic notch (below the tendon of the obturator internus), 13 into the thyroid foramen, and 8 upon the pubes.

In the **Reduction** of dislocations of the hip-joint, two methods may be employed, *extension* or *manipulation.* In extension, forcible traction is made by pulleys or otherwise in the direction of the axis of the limb, overcoming by main force any obstacle arising from muscular contraction or the mechanical resistance of ligaments. In manipulation force is avoided, the Surgeon's object being to relax the ligaments which offer a mechanical obstruction to reduction, and to disentangle the head of the bone from its abnormal position, and by impressing on it various rotatory movements, each adapted to the particular case, to bring it back into the acetabulum. Manipulation is mentioned by Hippocrates. The earliest modern description is by Thomas Anderson, Surgeon, of Leith, in the third volume of "The Medical and Philosophical Com-

mentaries" for 1775. He describes two cases, one of dislocation on the foramen ovale in a man; the other a dislocation of the dorsum ilii in a boy. In the first case the pulleys had been used ineffectually several times, when the "lacque" slipping, their use was discontinued. Mr. Anderson says: "I was convinced that attempting the reduction in the common method, with the thigh extended, was improper, as the muscles were put upon the stretch, the action of which is perhaps sufficient to overcome any extension we can employ. But by bringing the thigh to near a right angle with the trunk, by which the muscles would be greatly relaxed, I imagined the reduction might more readily take place, and with much less extension. *I raised the thigh to about a right angle with the trunk*, and, with my right hand at the ham, laid hold of the thigh, and made what extension I could. At the same time that I did this, with my left hand at the head and inside of the thigh, I pressed it towards the acetabulum, while my right gave the femur *a little circular turn*, so as to bring the rotula inwards to its natural situation, and at the second attempt it went in with a snap." In the second case, the reduction was not attempted till the eighteenth day after the accident. The patient was laid across the bed, and *the thigh raised so as to form an acute angle* with the trunk. In this situation, the knee of the dislocated limb lay considerably over the sound thigh. "Considerable extension was then made; with my left hand I laid hold of the middle of the leg which I brought inwards. By this *the femur made a circular turn*, which directed its head towards the acetabulum, into which it went with a sensible noise" (pp. 426—428).

The method was, however, first distinctly advocated by Nathan Smith, in 1831, and extended by Reid, of Rochester (U.S.A.), in 1851; but it was not until the publication of Bigelow's work that the scientific principles of manipulation were fully laid down. At the present time no Surgeon would resort to extension by means of pulleys in a *recent* dislocation of the hip without having first attempted reduction by manipulation. In those of *old standing*, extension by means of the pulley is still required, as by manipulation sufficient force cannot be exerted to overcome those secondary causes of resistance that become developed in such cases.

After-Treatment.—The fact of the reduction being accomplished is ascertained by comparing the bony points of the limb with those of the opposite side, and seeing if they correspond. The patient should be kept in bed for three weeks. During the first fortnight the limb is fixed on a long splint, after which passive movement is practised.

I shall describe both methods of reduction in connection with each of the principal forms of dislocation of the hip.

1. **Dorsal Dislocations**, or **Dislocation Upwards and Backwards.**—*Causes.*—The dorsal dislocations are occasioned by violence acting upon the limb while flexed and slightly adducted, or according to some authorities, abducted: as when a person is struck on the back with a heavy weight whilst kneeling, or is thrown forwards, or falls whilst carrying a heavy load upon his shoulders, when the upper and posterior part of the joint receives the whole strain. Thus, in a case under my care in University College Hospital, it was caused by a heavy weight falling from a crane upon a man's back as he was kneeling on one knee and reaching down to put a ticket on the side of a railway-truck. In another case it was caused by the patient's falling between the carriage and platform in a railway station in such a way that he lay on his

side on the footboard with his knee against the platform and his back against the carriage. As the carriage slowly moved, his leg became flexed, and the space being insufficient, the head of the bone was pushed out of the socket. Bigelow states that if the femur is flexed at right angles, and thrust directly backwards with sufficient force, the head will tend to pass between the obturator internus and the pyriformis. At an angle of forty-five degrees it may be thrust upwards and backwards above the pyriformis. Both these displacements would give rise to the symptoms of dislocation upon the dorsum ilii. In extreme flexion, or in cases complicated by forcible inward rotation, the head tends to pass out beneath the tendon of the obturator internus, and we then have the form of dorsal dislocation formerly described as into the sciatic notch.

Pathological Anatomy.—The capsule is ruptured below or more rarely behind, but the ilio-femoral ligament is intact in all dorsal dislocations. The ligamentum teres is mostly torn, but not necessarily in all cases. Dupuytren and Sédillot both mention cases in which this ligament escaped without rupture. In dislocation on the dorsum ilii, the head will be found lying in a variable position on the ilium, above and behind the acetabulum. The trochanter is directed forwards, being held in that position chiefly by the unruptured external band of the ilio-femoral ligament, which is very tense. The muscles are torn to a varying degree in different cases. Astley Cooper found the gemelli, obturators and quadratus, completely torn, and the pectineus slightly torn in one case. Syme found the gluteus maximus extensively torn, with the head of the bone imbedded in it; the gluteus minimus, the pyriformis, and the gemellus superior lacerated; and the head of the femur lying upon the gemelli and the great sciatic nerve. MacCarthy found the deeper fibres of the gluteus maximus torn by the head of the bone, which was lying with its anterior part on the brim of the acetabulum, with the lowermost fibres of the gluteus minimus interposed, and the dimple for the ligamentum teres directed backwards and inwards. The posterior fibres of the gluteus medius were also lacerated, and the pyriformis, obturator internus, and gemelli had been completely torn from their pelvic attachments. The quadratus femoris was uninjured. The capsule had given way posteriorly; in front and above it was intact. Although some fibres of the ligamentum teres had been ruptured, the ligament still resisted all attempts to break it. The ilio-femoral and pubo-femoral bands were uninjured, notwithstanding that the acetabulum had separated into its three component parts, the fracture also traversing the ilio-pectineal eminence. The lowermost fibres of the external oblique muscle of the abdomen, and some fibres of the sartorius, psoas magnus, and iliacus internus muscles were also ruptured. In all these cases it is evident that the bone had passed out above the obturator; in the last this muscle was torn.

In dislocations *below the tendon of the obturator internus* the position assumed by the bone is best explained by the accompanying figures taken from Bigelow's work on the Hip. Fig. 271 shows the normal position of the muscle behind the head and neck of the bone. It is evident that in a state of extreme flexion, or of moderate flexion with forcible internal rotation, the head might be made to pass out beneath the muscle. Immediately after the accident the limb is almost invariably extended either in lifting the patient or in placing him on his back. The ilio-femoral ligament being untorn, and

consequently the neck of the femur being more or less firmly fixed, the head moves upwards as the limb is extended till it comes to lie above the muscle in the position shown in Fig. 272, the obturator internus now lying in front of the neck of the bone and passing over it, thus limiting the displacement upwards. The injury to surrounding muscles is very various. Billard d'Angers found the gluteus maximus and medius lacerated and the gemelli torn, probably from the strain they had been subjected to by the position of the obturator. MacCarthy found the gluteus maximus not torn, but the bursa between it and the vastus externus was ruptured and filled with blood. The sheath of the great sciatic nerve was also distended with blood, and the nerve fibres separated from one another. The posterior fibres of the gluteus minimus were torn and the areolar tissue beneath the muscle filled with blood. The quadratus femoris muscle was torn completely in two, and the uppermost fibres of the abductor magnus, and some fibres of the gemelli and obturator

Fig. 271.—Pelvis and Head of the Femur with obturator internus in natural position. (Bigelow.)

Fig. 272.—Pelvis and Head of Femur showing dislocation below the tendon of the obturator, with secondary displacement of the head upwards, and abnormal position of the obturator internus. (Bigelow.)

internus muscles, were lacerated. The capsule was perfect in front and above, but torn at the most posterior part. The ligamentum teres had been torn off close to the femoral attachment.

The accompanying drawing (Fig. 273) is from a case which was admitted into University College Hospital. The patient died from other injuries a few hours after admission. The dislocation was reduced without the slightest difficulty by manipulation and showed no tendency to slip out again, though the man was very restless before death. The dislocation was easily reproduced after the limb had been dissected and rigor mortis had passed off. A considerable extravasation of blood was found beneath the gluteus maximus. The only muscle torn was the gemellus inferior, the upper border of the quadratus was slightly bruised, and the lower border of the gluteus minimus was also marked by a little extravasated blood, apparently from the pressure of the head of the bone in its abnormal position, and there was extravasated blood in the sheath of the great sciatic nerve. A small fragment had been chipped from the margin of the acetabulum, but was firmly fixed by the capsule.

Symptoms.—If the head of the bone have been displaced *above the obturator and upon the dorsum of the ilium*, the hip will be found to be a good deal distorted, the gluteal region being somewhat prominent, and the upper part of the thigh enlarged, in consequence of the approximation of the muscular attachments, so as to give an appearance of widening to the hip. The head of the bone can be felt in its new situation, more especially on rotating the limb ; the trochanter is less prominent than natural, usually lying close against the brim of the acetabulum, and being turned forwards ; it lies considerably above "Nélaton's line" drawn from the anterior superior spine of the ilium to the tuberosity of the ischium ; there is marked shortening, varying from one to two inches in some cases, perhaps even as much as three

Fig. 272.—Dorsal Dislocation below the tendon. *g*, *g'*, *g''*, Gluteus max., medius, and minimus : *p*, pyriformis ; *a*, attachment of capsule ; *t*, trochanter ; *ge i*, gemellus inferior ; *q*, quadratus ; *n*, great sciatic nerve ; *ad*, adductor magnus ; *b*, biceps ; *ob*, obturator internus ; *ge s*, gemellus superior.

inches. The amount of shortening will necessarily depend upon the distance to which the head of the bone is thrown *upwards* on the dorsum. The position of the limb is remarkable, being distinctly rotated inwards, with the thigh slightly bent upon the abdomen, and the leg upon the thigh, so that the knee is semi-flexed, and raised from the surface on which the patient is lying. The foot is inverted, so that the ball of the great toe rests on the instep or against the ankle of the sound limb ; and the heel is somewhat raised. The axis of the dislocated thigh is directed across the lower third of the sound thigh. The movements of the joint are greatly impaired ; abduction and eversion are not practicable, but inversion, adduction, and a certain amount of flexion upon the abdomen, can be practised. When the patient is lying flat, with the knee slightly raised and advanced, the lumbar spine is on

its proper level; but if an attempt be made to straighten the knee, so that the limb lies flat, the lumbar spine will arch forwards.

The slight flexion, the rotation inwards, and the adduction are all due to the position in which the neck of the bone is held by the ilio-femoral ligament: flexion and adduction are easy because by approximating the intertrochanteric line to the anterior inferior iliac spine they relax the ligament.

When the head of the bone has escaped *below the tendon of the obturator* we have the dislocation formerly described as into the sciatic notch, and to which the name "sciatic" is still usually applied. If seen immediately after the accident there may be extreme flexion and adduction, the dislocated limb crossing the sound thigh near the groin, but usually before the Surgeon sees the case the limb has been brought down so that the head has gone up behind the obturator. The symptoms then resemble those of the dislocation on to the dorsum ilii, differing chiefly in degree. The inversion of the knee and foot are, according to Bigelow, more marked, and consequently the trochanter is less prominent than in the dislocation on the ilium. In some cases, however, the inversion is less marked than in others. The shortening is very much less, as it is limited by the obturator internus in its abnormal position, and consequently the trochanter is but little above Nélaton's line; it seldom exceeds an inch and is usually not so much. The position of the limb will depend upon the degree to which the thigh has been extended since the accident. In the erect position the weight of the limb brings it down so that the axis of the thigh may be directed across the sound knee, and the toes of the injured side may rest on those of the opposite foot (Fig. 274). Thus it may closely resemble a dislocation on the dorsum ilii, the most important difference being the small amount of shortening when the head has escaped below the tendon. By violent manipulation or extension the obturator internus may be torn, and the lower dislocation may thus be converted into one on the dorsum ilii.

Fig. 274.— Dislocation below the Tendon. Much Inversion. (Bigelow.)

The *Diagnosis* of this form of dislocation is easy in proportion as the head of the bone lies high on the dorsum ilii. The lower it is placed the more difficult does the detection of the displacement become, and the greater the risk of its being overlooked altogether, or mistaken for a sprain. In ordinary cases of fracture of the neck of the thigh-bone, the eversion of the limb at once shows that the head of the bone is not dislocated on the ilium. The only severe injury of the hip with which the dislocation upwards and backwards can be confounded is the rare case of *fracture of the neck of the thigh-bone, with inversion of the limb.* In this accident, the increased mobility and the existence of crepitus will enable the Surgeon to make the diagnosis. Should the case, however, be one of *impacted extracapsular fracture, with inversion,* then the difficulty of diagnosis is undoubtedly great. A correct conclusion may, however, be arrived at by observing that in the fracture the flattened trochanter is approximated to, and is nearly in a perpendicular line with, the anterior superior spine of the ilium; whilst in the dislocation the trochanter is diagonally behind that process of bone, and the head of the thigh-

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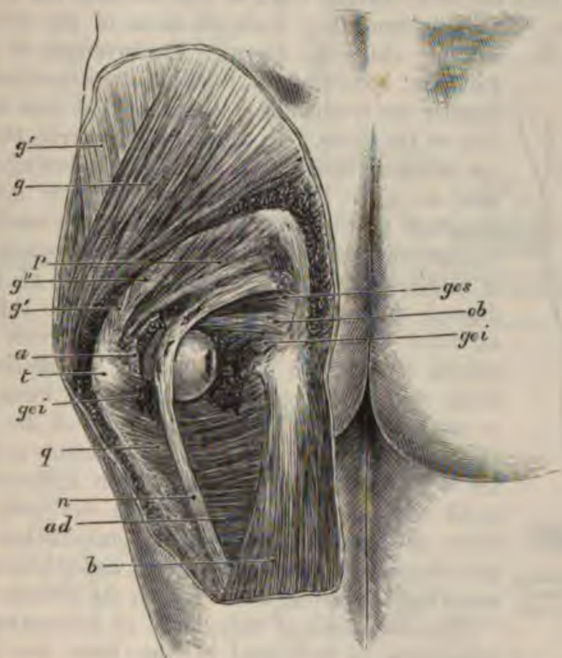

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its proper level; but if an attempt be made to straighten the knee, so that the limb lies flat, the lumbar spine will arch forwards.

The slight flexion, the rotation inwards, and the adduction are all due to the position in which the neck of the bone is held by the ilio-femoral ligament; flexion and adduction are easy because by approximating the intertrochanteric line to the anterior inferior iliac spine they relax the ligament.

When the head of the bone has escaped *below the tendon of the obturator* we have the dislocation formerly described as into the sciatic notch, and to which the name "sciatic" is still usually applied. If seen immediately after the accident there may be extreme flexion and adduction, the dislocated limb crossing the sound thigh near the groin, but usually before the Surgeon sees the case the limb has been brought down so that the head has gone up behind the obturator. The symptoms then resemble those of the dislocation on to the dorsum ilii, differing chiefly in degree. The inversion of the knee and foot are, according to Bigelow, more marked, and consequently the trochanter is less prominent than in the dislocation on the ilium. In some cases, however, the inversion is less marked than in others. The shortening is very much less, as it is limited by the obturator internus in its abnormal position, and consequently the trochanter is but little above Nélaton's line; it seldom exceeds an inch and is usually not so much. The position of the limb will depend upon the degree to which the thigh has been extended since the accident. In the erect position the weight of the limb brings it down so that the axis of the thigh may be directed across the sound knee, and the toes of the injured side may rest on those of the opposite foot (Fig. 274). Thus it may closely resemble a dislocation on the dorsum ilii, the most important difference being the small amount of shortening when the head has escaped below the tendon. By violent manipulation or extension the obturator internus may be torn, and the lower dislocation may thus be converted into one on the dorsum ilii.

Fig. 274.—Dislocation below the Tendon. Much inversion. (Bigelow.)

The *Diagnosis* of this form of dislocation is easy in proportion as the head of the bone lies high on the dorsum ilii. The lower it is placed the more difficult does the detection of the displacement become, and the greater the risk of its being overlooked altogether, or mistaken for a sprain. In ordinary cases of fracture of the neck of the thigh-bone, the eversion of the limb at once shows that the head of the bone is not dislocated on the ilium. The only severe injury of the hip with which the dislocation upwards and backwards can be confounded is the rare case of *fracture of the neck of the thigh-bone, with inversion of the limb.* In this accident, the increased mobility and the existence of crepitus will enable the Surgeon to make the diagnosis. Should the case, however, be one of *impacted extracapsular fracture, with inversion,* then the difficulty of diagnosis is undoubtedly great. A correct conclusion may, however, be arrived at by observing that in the fracture the flattened trochanter is approximated to, and is nearly in a perpendicular line with, the anterior superior spine of the ilium; whilst in the dislocation the trochanter is diagonally behind that process of bone, and the head of the thigh-

ne can be felt in its new situation by deep manipulation of the gluteal gion.

Reduction of Dorsal Dislocation by Manipulation.—The patient must

Fig. 275.—Reduction of a Dorsal Dislocation of the Hip by Traction.

Fig. 276.—Reduction of a Dislocation by Rotation. The Thigh is flexed, slightly adducted an rotated inwards, as in the first stage of reduction of a dorsal dislocation.

laid upon his back on a mattress on the floor and fully anæsthetized, the rgeon standing on the injured side. There are two chief ways in which uction may be effected, viz., by *traction* and by *rotation*.

Traction is thus performed :—

Flex the thigh upon the abdomen, bending the limb at the knee to a right angle (Fig. 275). The flexion relaxes the ilio-femoral ligament, and the relaxation may be further increased by slight adduction ; then rotate very slightly inwards ; that is to say, move the foot away from the middle line while the knee is held steady. This disengages the head from behind the socket ; slight traction in the line of the femur will then usually bring the bone into position ; if more force is required the Surgeon may place his foot, covered only with a stocking, on the anterior superior spinous process, to steady the pelvis while he raises the bent knee. In the great majority of cases reduction will easily be effected by this plan.

Fig. 277.—Dorsal Dislocation. Reduction by Rotation. The limb has been flexed and abducted, and it remains only to rotate it outwards, and so to render the outer Branch of the Y-ligament tense. (Bigelow.)

Rotation is thus performed :—The Surgeon, standing on the injured side, grasps the ankle with one hand and the leg below the knee in the other as in Fig. 276. He then steadily flexes the thigh upon the abdomen, so that the head of the bone is lifted out from behind the acetabulum and the ilio-femoral ligament relaxed. At the same time that the thigh is flexed it is better to keep it slightly adducted. The limb must now be slowly abducted, and finally rotated outwards by bringing the foot of the injured side over the sound leg. By this manœuvre the head is made to revolve around the great trochanter, which is fixed by the outer branch of the Y-ligament, and to rise into its articular cavity (Fig. 277). Finally the limb is brought down parallel to the other. Bigelow has summarised the movements necessary to effect reduction this way in the following words, "*Lift up, bend out, roll out.*"

Reduction by Extension, according to Astley Cooper's method, is effected in the following manner. The patient, having been put under the influence of chloroform, is laid on his back upon a strong table. One staple should then be fixed in the floor near the head of the bed at the side corresponding to that of the dislocated limb, while another staple is placed in the wall at the foot, above the level of the body, in a direct line with the axis of the limb and about twelve feet from the other. The counter-extending force must then be made by a jack-towel or a padded leather belt passed between the injured thigh and the perinæum, and fixed to the staple in the floor. The pulleys must now be attached to proper straps, or to a towel fixed with a clove-hitch knot immediately above the knee, at one end ; the other extremity being attached to the staple in the wall, which should be so situated as to be continuous with the axis of the lower part of the limb. The knee being then slightly bent and rotated inwards, traction is applied slowly and steadily until the head of the bone has approached the acetabulum, when the Surgeon rotates the limb outwards so that the head may slip into its socket (Fig. 278). This method is seldom, if ever, required in recent dis

locations. Should it be necessary, as in an old dislocation, it would be better to flex the thigh more than is shown in the figure after the bone had been brought down as far as possible by extension in the axis of the limb.

Reduction of the Dislocation below the Tendon of the Obturator is effected by the same processes of manipulation as in the other form of the dorsal dislocation. The first method, that of *traction*, is usually at once

Fig. 278.—Reduction of Ilio-sciatic Dislocation by Extension.

successful. Astley Cooper found great difficulty in the reduction of this dislocation, and he, Lisfranc and other Surgeons, have failed to reduce it by extension. They believed that the difficulty arose from the head of the bone sinking into the great sciatic notch. The fallacy of this view and the part played by the obturator internus in resisting reduction by extension in the axis of the limb has already been pointed out. Should *extension* be necessary, it must be made with the thigh flexed at a right angle to the trunk.

In either of these dislocations, if difficulty arise in raising the bone over the edge of the acetabulum, recourse may be had to the plan recommended by Astley Cooper, of lifting the head of the bone over the edge of the acetabulum by means of a round towel placed under the upper part of the thigh and over the shoulders of an assistant, who, first stooping and at the same time resting his foot on the patient's pelvis, should then raise his shoulders and draw the bone towards its socket.

Fig. 279.—Dislocation Downwards and Outwards towards the Tuberosity below Tendon. (Bigelow.)

Dislocation downwards and outwards towards the tuberosity of the ischium is described by Bigelow as closely allied to the dorsal dislocation below the tendon. It arises from *causes* similar to those giving rise to a dorsal dislocation, applied when the thigh is fully flexed on the abdomen. The head of the bone bursts out through the capsule and passes below the tendon of the obturator internus, rupturing the gemellus inferior and the quadratus, and comes to lie close to the tuberosity of the ischium. It can be felt in this situation; there is extreme flexion and adduction and rotation inwards (Fig. 279). On extending the limb, the neck of the bone remaining fixed by the ilio-femoral ligament, the head passes upwards behind the tendon of the obturator internus, and the dislocation is thus converted into an ordinary dorsal below the tendon."

Dislocations of the head of the femur directly backwards with fracture of the brim of the acetabulum may occur when a heavy weight falls on the back of a person who is kneeling. In this case the pelvis is driven down violently on the femur, which is fixed against the ground at its lower end. The impact of the blow drives the posterior part of the brim of the acetabulum against the head of the femur, and this is thrust through the capsule at its posterior part. It is, perhaps, rather the pelvis that is thrust forwards than the femur backwards, but the result is the displacement of the head of the bone, which is lodged directly behind the cotyloid cavity.

2. **Dislocations Downwards** or **Thyroid Dislocations.**—*Causes.*—This dislocation appears to be occasioned by the limb being suddenly and violently abducted, as by falls with the legs widely separated ; in consequence of which the head of the bone is tilted against the inner side of the capsule, and, rupturing this, is thrown on the thyroid foramen.

Pathological Anatomy.—The head of the bone escapes by a laceration of

Fig. 280.—Thyroid Dislocation. (Bigelow.)

Fig. 281.—Reduction by Manipulation in Thyroid Dislocation. Rotation and Circumduction Inwards of Head of Femur. (Bigelow.)

the inner side of the capsule where it is thin and membranous. The ilio-femoral ligament is untorn, and holds the root of the neck up while the head descends, and passes somewhat inwards, consequently the femur is flexed and abducted. The round ligament is torn. The pectineus and adductor brevis muscles have been found to be lacerated in this injury.

Symptoms.—The hip is flattened, and the prominence of the trochanter completely absent, or indeed replaced by a depression. The limb is lengthened by about two inches, advanced before the other, and considerably abducted (Fig. 280). The knee is bent and incapable of extension ; the foot usually points forwards, but is sometimes slightly everted and widely separated from its fellow. When the patient stands, the body is bent forwards, partly to accommodate the pelvis to the flexed position of the limb dependent on the ilio-femoral ligament, and partly on account of the tension of the psoas and iliacus muscles ; in a thin person the bone may be felt in its new situation.

When he lies on his back the knee is much raised, the thigh being flexed according to Bigelow to an angle of 35°.

Reduction by Manipulation may be done by rotation or traction as follows. *Traction* may be done thus: the Surgeon flexes the limb and abducts it, and then placing his foot upon the side of the pelvis, pulls or jerks the thigh in the direction in which the head is required to go to reach the socket. If more force is required a towel may be put round the lower part of the thigh. In *rotation* the limb, having been flexed on the abdomen so as to bring it into a perpendicular position, must be slightly abducted so as to disengage the head of the bone. The thigh is then to be strongly rotated inwards and adducted, the knee being carried towards the floor (Fig. 281).

Reduction by Extension is done as follows:—The patient is laid on his back; a counter-extending girth, or towel, is then placed round the pelvis and fixed firmly to a staple next to the sound side of the patient. A padded

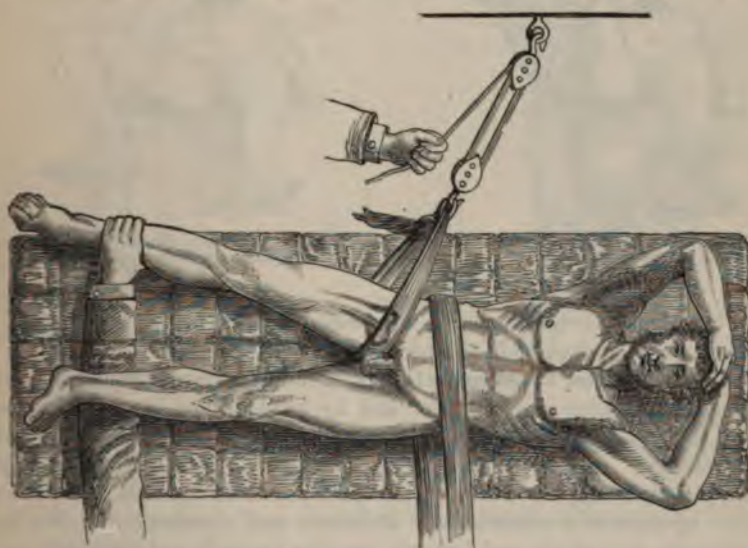

Fig. 282.—Reduction of Dislocation into Thyroid Foramen by Extension.

girth is then to be placed between the perinæum and the upper part of the dislocated thigh. From this, extension is made by means of the tourniquet or the pulleys, which are fixed to a staple at a little distance from the injured side of the patient. Extension having then been made to such a degree as to elevate the head of the bone from the depression in which it lies, the Surgeon passes his hand behind the sound leg, and, seizing the ankle of the injured limb, presses it backwards and draws it towards the mesial line, taking care to keep the knee straight, and thus throwing the head of the bone into the acetabulum by the action of a long lever (Fig. 282).

The following are more rare forms of dislocation downwards:—

The head of the thigh-bone may be thrown **directly downwards,** so as to rest *on the lower margin of the acetabulum,* between the sciatic notch and the thyroid foramen. Two cases of this injury have been recorded by Gurney of Camborne, and one by Luke. In it there is less eversion of the limb than

in the thyroid dislocation (Fig. 283). Bigelow has pointed out that the head of the bone, when thrown below the lower margin of the acetabulum, may be further displaced; either backwards on the dorsum ilii, or forwards to the thyroid foramen. In extreme flexion, however, the head may pass down as far as the *tuberosity or the ascending ramus of the ischium;* in the former case the limb is everted, in the latter inverted, and in all cases flexed. The head of the bone may pass also **into the perinæum**, so as to be felt in its abnormal situation behind the scrotum. It has been known to compress the urethra, and thus give rise to retention of urine. The thigh is extremely abducted and stands out at a right angle with the body; and the toes may be

Fig. 283.—Dislocation directly downwards. (Bigelow.)

Fig. 284.—Dislocation downwards and inwards towards Perinæum. (Bigelow.)

either inverted or everted—which is ascribed by Bigelow to the want of firm bearing for the trochanter in the perinæum (Fig. 284).

In the **Reduction by Manipulation** of these two rare forms of dislocation downwards, the thigh is to be bent and its head guided towards the socket. During this, the dislocation is sometimes converted into one of the thyroid or dorsal variety. In the dislocations downwards, vertical traction and slight inward rotation may be used; in the dislocations downwards and outwards, traction upwards and inwards, with abduction and rotation outwards; in the displacement downwards and inwards, traction upwards and outwards.

Probably allied to these forms of dislocation is that in which the head of the bone has been found thrown **downwards and backwards towards the lesser sciatic notch.** In these cases there is considerable shortening, but the position of the limb appears to vary. In an instance that occurred to Keate, the limb was abducted and the toes turned outwards. In a case reported by Wormald, the limb was turned inwards. Although the limb is described as shortened in these cases, Warren has related a case in which it was elongated.

Dislocation Upwards or Pubic Dislocation.—The *Cause* of this dislocation is either direct violence applied to the back of the thigh whilst the limb is abducted; or it arises from the patient making a false step in walking, and suddenly throwing his body backwards in order to avoid a fall, twisting and displacing the limb.

Pathological Anatomy.—The capsule is lacerated at its inner aspect, the ilio-femoral ligament remaining untorn and causing rotation of the limb outwards: the obturator internus is tense and holds the limb backwards, being the

chief agent in preventing flexion ; the gemelli are stretched or torn, and the quadratus femoris has also been found to be ruptured. In one case related by Astley Cooper, Poupart's ligament was torn up, and in another the pectineus and adductors were torn ; but whether this was done by the dislocation or by the direct injury that occasioned it is uncertain.

Symptoms.—The dislocation upwards **on the Pubic Bone** presents very unequivocal signs. The hip is flattened ; the head of the bone can be distinctly felt lying in its new situation above Poupart's ligament, to the outer side of the femoral vessels, where it may be made to roll by rotating the limb. The thigh and knee are slightly flexed, rotated outwards, and abducted ; the

Fig. 285.—Pubic Dislocation. (Bigelow.)

Fig. 286.—Pubic Dislocation. Head of Bone in Groin suspended by Y-ligament. (Bigelow.)

limb, which is separated from its fellow, is shortened to the extent of an inch (Figs. 285, 286).

The **Reduction by Manipulation** can be effected by traction and rotation, or by rotation alone. The former is effected by drawing the limb downwards, and at the same time raising it up so as to flex it gradually on the abdomen as the head of the femur becomes disentangled from its position. It may then be rotated inwards, and the head of the bone thus directed towards the acetabulum.

By *rotation.*—Bigelow recommends it to be thus accomplished : semi-flex the thigh so as to relax the ilio-femoral ligament and to bring the head down from the pubes ; then abduct and rotate inwards to disengage it completely ; lastly, while rotating inwards and drawing on the thigh, carry the knee inwards and downwards to its place by the side of its fellow.

With regard to the **Reduction by Extension**, Astley Cooper advises that the patient should lie upon his back with his legs widely separated ; and that, counter-extension being then made by a girth carried between the perinæum and the injured thigh, and fixed to a staple in front of and above the body, the pulleys should be fixed upon the lower part of the thigh, and the

extension made downwards and backwards. After this has been continued for a sufficient time, an assistant lifts the head of the bone by means of a towel over the brim of the acetabulum (Fig. 287).

Fig. 287.—Reduction of Pubic Dislocation by Extension.

The head of the thigh-bone may also be thrown **under the anterior inferior spinous process,** constituting the **Subspinous Dislocation** of Bigelow. There is shortening of the limb, which is everted, but less abducted or advanced than in the dislocation on the pubes. The head of the bone can be felt in its new situation. One peculiarity of this dislocation is that in some of the recorded cases the patient has been able to walk immediately after the accident. Bigelow explains this by the position of the Y-ligament over the upper part of the neck of the femur (Fig. 288). Reduction of the dislocation is accomplished in the same way as in the pubic form.

Fig. 288.—Subspinous Dislocation. The Y-ligament is stretched across the Neck of the Bone, which lies beneath it. (Bigelow.)

In the dislocations above described the Y-ligament remains entire. Bigelow describes also **Supraspinous dislocation** with or without rupture of the outer branch of the ligament. In this dislocation the head of the bone leaves the socket on the outer side of the ilio-femoral ligament. If this be not ruptured, the dislocation is called by him *anterior oblique:* in it, the thigh lies across the upper part of the corresponding limb, and is firmly locked in that position, with much shortening and some eversion. Reduction may be effected by extension of the limb and increased circumduction across the symphysis, with a little eversion if necessary to dislodge the head of the bone. By inward rotation, the head of the bone is thrown on the dorsum.

In the true *supraspinous dislocation*, the outer branch of the Y-ligament is ruptured; the limb is shortened and everted. In a case related by Cummins, the limb was shortened three inches. Reduction may be effected by circumduction inwards and eversion, by which the dislocation is rendered dorsal, and may then be reduced as already directed.

Everted Dorsal Dislocation may occur when, in dislocation on the dorsum, the outer branch of the Y-ligament is broken ; the integrity of this portion being necessary for the inversion of the limb.

Irregular Dislocations of the head of the thigh-bone occur when the Y-ligament is wholly ruptured. The displacement may take place in any of the above-described directions ; but the characters are inconstant.

Reduction of old Dislocations of the Hip-Joint is attended not only with great difficulty, but with no small amount of danger. The probability of effecting reduction rapidly decreases with the length of time that the bone has been left unreduced, and more rapidly in some dislocations than in others. Thus it is easier to reduce an old dislocation on the dorsum ilii than one below the tendon of the obturator internus. Dislocation of the head of the thigh-bone on the dorsum of the ilium may usually be reduced without any great difficulty, up to the end of the first fortnight. After that time the difficulty increases considerably ; and, although reduction has frequently been effected in these cases up to the sixth or eighth week, yet it has also not unfrequently failed, notwithstanding repeated attempts. After two months have elapsed, the reduction is a work not only of great uncertainty, but also of no slight danger from risk of suppuration in the soft parts, or fracture of the femur. But cases have been reported, and are referred to at p. 650, in which these dislocations have been reduced at a much later period, even as late as six or nine months. The method of manipulation should be employed with complete anæsthesia, and if this fail extension must be tried. In a case recently in University College Hospital under the care of Christopher Heath, a dorsal dislocation was successfully reduced by manipulation on the 106th day. The success which has followed operative interference in the reduction of old dislocations of the shoulder would seem to warrant the application of the same treatment in the case of the hip, should manipulation and extension fail. If the bone be left permanently unreduced, it will in time acquire considerable mobility, more particularly in the lower dorsal dislocation, the patient walking readily with a shortened but otherwise useful limb. Should the limb be useless from great adduction and flexion, relief might be given by subcutaneous section of the neck, which would restore parallelism of the limb. In the case of a thyroid dislocation which had been unreduced for twenty months, W. MacCormac restored the utility of the limb by excising the head of the bone.

In the attempt to reduce old dislocations of the hip-joint the soft parts have been extensively lacerated in some cases ; in others fatal inflammation around the joint has ensued ; and, in twelve cases with which I am acquainted, the thigh-bone was fractured. This accident has happened to Surgeons of the highest eminence. In most of these cases the bone gave way at its neck or below the trochanters ; the dislocation was of course left unreduced, but the patients recovered without difficulty, the fracture being treated in the usual way. The cause of the fracture appears usually to have been the employment of force in a transverse or rotatory manner, after extension had been kept up for some considerable time. There is no proof that undue violence was used in any of these cases. It is probable that in some the femur had become atrophied and weakened by disuse of the limb, thus readily snapping.

The **Complication of Fracture of the Femur with Dislocation of the Hip-Joint** occasions a very serious state of things that may baffle the efforts

of the most skilful Surgeon. The line of practice to be adopted must depend in a great measure on the seat of fracture. If this be below the middle of the thigh, the limb should be put up tightly in splints, and an attempt made under chloroform to reduce the dislocation in the ordinary way, by manipulation or by pulleys applied over the splints. If the fracture be high up, near or at the neck, the patient should be put under chloroform, and an attempt should then be made by pressure on the dislocated head and manipulation to replace it. It is possible that this might be effected, as in similar injuries of the humerus, with comparatively little trouble. Should reduction in this way not be practicable, we may adopt the plan successfully employed by Badley, who, in a lad of eighteen, with dislocation on the dorsum ilii and fracture of the displaced bone, allowed union of the fracture to take place, and then, at the end of five weeks, effected reduction.

Simultaneous Dislocation of both Hips, in different directions, or of one hip with fracture of the opposite thigh-bone, has been met with in some rare instances.

Spontaneous Dislocation from distension of the joint is almost exclusively met with in the hip. In most cases it has occurred in children during an attack of acute rheumatism or typhoid fever. The patient having necessarily been confined to bed, and usually very ill, the accident has frequently been overlooked until he tried to walk some two or three weeks, or perhaps longer, after the dislocation occurred. In all recorded cases the head of the bone has been displaced backwards and upwards. The treatment of these cases is to attempt to reduce the dislocation by the ordinary means. If these fail, a very useful limb will usually be obtained by passive motion and the application of a weight-extension apparatus at night. If this fails, and the limb remains much adducted and useless, after a year or two the position of the limb may be greatly improved by excising the head of the bone, an operation which has been performed with excellent results by Rawdon of Liverpool, and Adams of London. There seems no reason, however, to adopt this somewhat severe proceeding till it is quite evident that a useful limb cannot be obtained without it. In a case of this kind in University College Hospital, a large extravasation of blood followed the attempted reduction, which finally suppurated. The incision to evacuate the pus exposed the head of the bone, which was accordingly removed, and the patient, a girl aged about twelve, made an excellent recovery with a useful limb, upon which she could bear the whole weight of her body.

Congenital Dislocation of the hip is by no means rare; it occurs most frequently in girls, and may affect either one hip or both. The dislocation is almost invariably on the dorsum ilii, though other varieties have been met with. When it is double, the deformity, being symmetrical, is seldom recognized till the child begins to walk. The signs of the affection are in most cases clearly marked. The situation of the heads of the bones behind their natural position causes the pelvis when the patient is erect to be tilted forwards, carrying with it the last lumbar vertebra; to compensate for this there is a curve backwards in the upper lumbar and lower dorsal vertebræ. Thus the lumbar spine forms a very extreme curve, with its convexity forwards (lordosis); the trochanter is approximated to the anterior superior spine of the ilium, and the head of the bone may be seen on the dorsum ilii; the thigh seems shortened and is more or less adducted, and the toes may be straight or

directed inwards; the patient walks fairly well, but with a peculiar rolling or "waddling" gait.

Treatment.—If the patient walks well, nothing is needed, beyond in some cases the use of a properly constructed support. This should consist of a padded metal belt encircling the pelvis between the trochanter and the iliac crest, and having a moulded leather cap to fit the upper end of the femur; from this a steel rod passes up to the armpit and carries a crutch by which part of the weight of the body is transmitted to the displaced bone. Adams, following the original suggestion of Pravaz, has endeavoured to reduce the upward displacement of the femur by prolonged extension applied in the recumbent position; whilst Barwell has divided the adductor and other muscles with the same object. Hoffa and König have endeavoured to construct a cotyloid cavity by turning down flaps of periosteum and bone from the surface of the ilium. It seems, however, that these and other severe measures which have been recommended, are unnecessary in the majority of cases. When, however, the displacement is such as seriously to interfere with the power of walking, extension, with perhaps the division of muscles, may be practised with advantage.

Dislocations of the Patella are not frequently met with. They may, however, occur in four directions, viz., *outwards*, *inwards*, *edgewise* or *vertically*, and *upwards*.

1. The dislocation **Outwards** is the most common variety of the accident; the bone being thrown upon the outer side of the external condyle of the femur, with its axis directed somewhat backwards and downwards, so that the inner margin is directed forwards. The knee is flattened in front, and is broader than usual; the patella can be felt in its new situation, and the muscles which form the quadriceps extensor are rendered tense, more especially the vastus internus; the leg is sometimes extended, but more frequently the knee is slightly flexed. This accident usually happens from sudden muscular contraction, especially in persons who are knock-kneed. In some cases it has been occasioned by direct violence driving the bone out of its position. Most frequently, the patella is only partially displaced outwards, with some rotation of the bone in the same direction.

Holthouse has recorded a case of *congenital* dislocation of the patella outwards, in a boy aged seven. The right patella was so displaced that its inner articular facet rested on the outer condyle, and when the knee was flexed the dislocation became complete. There was no inclination inwards of either knee. The mother alleged that the condition had existed from birth, and that at first both knees were affected. The boy could run and jump as well as other children.

2. The dislocation **Inwards** is very rare; Malgaigne could find record of only one case of the kind.

In these lateral dislocations, *Reduction* may be effected by laying the patient on his back, bending the thigh on the abdomen, and raising the leg so as to relax the extensor muscles. The Surgeon then, by pressing down that edge of the patella which is furthest from the middle of the joint, raises the other edge, which, being tilted over the condyles, is immediately drawn into position by the action of the extensors.

In a case, recently in University College Hospital, of dislocation of the patella outwards associated with genu valgum, Macewen's operation for the

cure of the latter did not relieve the dislocation. The displacement of the patella was stated to be congenital, and there was an imperfect development of the external condyle of the femur and of the trochlear surface. A perfect cure was obtained by Bilton Pollard as follows :—The vastus externus was divided through an external incision, the trochlear surface was enlarged and deepened with a chisel, and finally through an incision on the inner side a portion of the capsule of the joint was excised. After the operation the patella kept in its proper position even during complete flexion of the knee.

3. A remarkable form of dislocation of the patella is that in which this bone becomes twisted upon its axis in such a way that it is placed **Vertically**, one of its edges being fixed between the condyles, and the other projecting under the skin, and pushing this forwards into a distinct tumour. Streubel, who has collected 120 cases of dislocation of the patella, states that one-sixth of these were vertical, and in about two-thirds of these the outer edge was forwards. In some cases the bone has been turned almost completely round, the posterior articular surface becoming partly anterior. The signs of this dislocation are evident, manual examination indicating the vertical displacement of the patella, with a deep depression on each side. The limb is completely extended, flexion being impossible.

This dislocation has most generally arisen from sharp blows or severe falls upon one edge of the patella, whilst the limb has been semiflexed, in consequence of which the bone appears to have been semi-rotated and fixed in its new position. Violent muscular contraction, however, conjoined with a twist of the leg, but without any blow, has been known to produce it in some cases.

The **Reduction** of this displacement has sometimes been very difficult; in other cases it has been readily effected; whilst in two or three instances it has been found to be quite impracticable, in spite of attempts, by means of elevators and the section of the muscles or of the ligamentum patellæ, to replace the bone. The cause of this difficulty of reduction is not very clear; it is certainly much greater than can be explained by simple muscular contraction, and may not improbably be owing to the aponeurotic structures which cover the bone becoming twisted or entangled under it, or, as Malgaigne supposes, to the superior angle of the bone being wedged in the *subcondyloid* space. Forcible flexion of the knee under an anæsthetic followed by sudden extension, while the projecting edge of the bone is forced into its place, appears to have answered better than any other method of treatment, and will probably seldom fail. If this do not succeed, reduction may perhaps be effected by the patient making a sudden and violent muscular effort at extension of the limb, or attempting to walk. In other cases the bone has been readily replaced by bending the leg, and rotating it on the axis of the tibia, at the same time that the patella is pressed into position.

In no case in which subcutaneous section of the tendon of the quadriceps extensor and of the ligamentum patellæ has been practised does it appear to have facilitated reduction, and in one the patient died of septic inflammation of the knee-joint. Should all other measures fail, the Surgeon may expose the bone with strict antiseptic precautions and endeavour to replace it by the use of an elevator and the division of resisting structures.

4. Dislocation of the patella **Upwards** can occur only in consequence of the rupture of its ligament. This accident, which is always accompanied by

effusion into the joint, requires the same treatment as a fractured a.

SLOCATIONS OF THE KNEE.—This joint, owing to the breadth of its llar surfaces, and the great strength of its ligaments, is seldom dislocated. 1 such an accident happens, it usually arises from falls from a great t, or by the patient jumping from a carriage in motion. The tibia may be iced in four directions: *to either side, forwards or backwards.* Besides displacements, the joint is subject to a partial luxation, dependent upon icement of one or both semilunar cartilages.

The **Lateral** dislocations of the tibia are the most common. They are 's *incomplete*, and are usually accompanied by a certain degree of rotation ie limb outwards. These displacements may be either **External** or **rnal**. In the first, the outer condyle of the femur rests upon the inner ılar surface of the tibia; in the other, the inner condyle is placed upon outer articular surface. In either case, the knee is slightly flexed; is a marked sulcus in the situation of the ligamentum patellæ, and eformity of the joint at once indicates the nature of the displacement.

these cases *Reduction* is always easy; indeed, it is occasionally effected e unaided efforts of the patient or by a bystander. It may be accom-ed by flexing the thigh upon the abdomen, then extending the leg, and, e same time, rotating the leg at the knee.

The dislocation **Backwards** may be *complete* or *incomplete*. When it is lete, the posterior ligament of the joint and the posterior crucial ligament orn, the muscles of the ham are stretched, the limb is shortened to the t of an inch and a half or two inches, and is semiflexed; the head of the can be felt in the ham, and there is a deep transverse depression in front e joint immediately below the patella.

The dislocation of the tibia **Forwards** is of more frequent occurrence the last. In it, the lower end of the femur projects into the ham, com-ing the vessels occasionally to such an extent as to arrest the circulation igh the leg, lacerating the ligaments, and stretching the muscles in ituation. The tibia projects forwards, its head forming a considerable inence on the anterior part of the knee, with a deep depression imme-ly above the patella, which is rendered more evident by the relaxation of xtensors of the thigh; the leg is usually rotated somewhat inwards or ards, and there is shortening to the extent of about two inches.

ese antero-posterior dislocations are very commonly incomplete. When s the case, they present the same symptoms, but in a less marked degree, ose which characterize the complete displacements.

the *Treatment* of these dislocations, extension should be made from the whilst the thigh is fixed in a semiflexed position. When the leg has drawn down sufficiently, proper manipulation will bring the bones into ion; splints must then be applied and the joint kept at rest for two or weeks, at the end of which time passive motion may be commenced.

mplications.—Dislocations of the knee-joint are more liable to serious lications than those of any other articulation. Not only are the ligaments and the muscles injured, but stretching, and perhaps laceration, of the teal vessels, followed by gangrene of the limb, may occur; or the injury be followed by destructive inflammation of the joint.

mpound Dislocation of the Knee-joint is one of the most serious

injuries to which the limbs are liable; the external wound being usually large, ragged, and accompanied by the protrusion of the condyles of the femur, with much laceration of the soft structures in the vicinity of the joint. These injuries, as a general rule, call imperatively for amputation; but cases have occurred in which the limb has been saved. Hence, if the patient be young, if the great vessels do not appear to have been seriously injured, and if the wound in the soft parts at the same time be not very extensive, nor much bruised, an attempt may be made to save the limb. In a case of this kind in a boy, A. White sawed off the end of the femur which protruded through the ham, and succeeded in saving the limb.

Congenital Dislocations of the Knee have occasionally been met with, with displacement of the tibia forwards. Cases of this kind have been recorded by Hilton, Guérin, Barwell, and Godlee. In some it was complicated by absence of the patella. In Barwell's case flexion was extremely limited, but by pushing the tibia backwards it could be carried to a considerable angle, and by fixing it in this position with a plaster of Paris bandage, the dislocation was completely cured at the end of six weeks.

Subluxation of the Knee, Displacement of a Semilunar Cartilage, or as it was termed by Hey "internal derangement of the knee-joint," is a common and very troublesome accident. It usually occurs whilst the knee is slightly flexed and the leg rotated inwards or outwards. Thus it may happen in rising from a kneeling position or in kicking a football (the limb affected being that upon which the patient is standing), or by striking the toe against a stone in walking. The patient is seized suddenly with acute and sickening pain in the knee, often so severe as to cause nausea or faintness. He may fall, but is conscious of having injured the knee before falling. On examination the limb will be found semiflexed and incapable of complete extension, any attempt to straighten it fully being attended with severe pain. In many cases a distinct fulness can be recognized on one side of the ligamentum patellæ in the hollow between the tibia and the femur, and there is tenderness at the same spot. In the course of a short time in most cases the joint becomes distended by inflammatory effusion.

This accident has been the subject of much investigation from the time it was first described by Hey. It has long been recognized that it is due to a displacement of one of the semilunar cartilages. The internal cartilage is far more commonly displaced than the external, although considering the firm attachments of the internal cartilage, the wide separation of its extremities and its considerable size, it might appear probable that the opposite would be the case. From anatomical considerations, Scott Lang is of opinion that the internal cartilage is displaced during flexion with rotation outwards, and the outer by flexion with rotation inwards. As the former is infinitely the more common movement, this would explain the comparative rarity of displacement of the outer cartilage. Usually the anterior extremity of the cartilage is partially displaced and loosened, but more rarely the dislocation is complete.

In a case of this kind found in the dissecting-room and recorded by Godlee, the external cartilage was completely torn away from its attachment to the capsule of the joint, and occupied a vertical position in the intercondyloid fossa. Occasionally the cartilage is torn as well as displaced, and a portion may even be completely detached.

Reduction.—This can usually be effected by flexing the joint at the same time that a strain is put upon the knee in such a direction as would tend to separate the condyle of the femur from the tibia on the affected side. A movement of rotation should then be given, outwards if the external cartilage is displaced, and inwards if the inner, and at the same time the limb may be suddenly straightened. This may sometimes be done when the muscles are off their guard, the patient's attention being directed elsewhere, but more commonly an anæsthetic is required. The evidence of complete reduction consists in the restoration of the power of extending the articulation. The synovitis that usually follows this injury requires to be treated by fomentations and rest on a splint. The cartilage is not fixed again as firmly as it was before the accident, and in the great majority of cases recurrence of the displacement takes place at intervals. The best means of preventing this is to support the knee either with an elastic knee-cap or a flannel bandage firmly applied. Should reduction prove impossible, or should the displacement return immediately when the patient uses his limb again, it is useless to try to fix the cartilage by prolonged rest. The patient should begin to use his leg freely as soon as the synovitis has subsided, and after a time the displaced cartilage seems to accommodate itself to its new position, and may give no further trouble. In some cases, however, the patient is seriously crippled by the frequent recurrence of the dislocation and the synovitis which follows. Under these circumstances the joint may be opened and the cartilage stitched down, or, if this be impossible, the displaced portion may be excised. Most successful results have followed this treatment in the hands of Annandale, H. W. Allingham and others, but no Surgeon is justified in undertaking the operation, unless it be done with full antiseptic precautions.

Rupture of the Posterior Crucial Ligament is an accident that occasionally occurs as the result of a violent blow on the anterior aspect of the head of the tibia, such as may be received in a railway accident when the patient is thrown forwards against the opposite seat. The symptoms are at first effusion of blood and synovia into the injured joint. When this is absorbed, it will be found that the knee is weak, giving way slightly when flexed in walking. When the patient is seated with the knee flexed to a right angle, and the foot firmly planted on the ground, if the tibia be grasped at its upper end and moved backwards and forwards, it will be found to be capable of a slight displacement backwards into the ham. The *Treatment* consists in supporting the knee with a properly fitted apparatus.

The **Head of the Fibula** has occasionally, though very rarely, been displaced by direct violence. Boyer and Sanson have each recorded a case of this kind. One such case has occurred in my own practice. It happened in a gentleman about 23 years of age, who, in descending an Alpine slope covered with snow, fell with one leg bent forcibly under him, so that he came down, as it were, in a sitting posture. The head of the fibula was thrown back off the articulating surface, and remained permanently in its new situation. The limb was somewhat weakened, so that the patient could not jump, but otherwise he suffered no inconvenience. The tendon of the biceps was very tense; and when I saw the case, some time after the accident, its traction effectually prevented all attempts at reduction.

Dislocations of the Ankle occur in consequence of displacement of the astragalus from the bones of the leg, whilst it continues to preserve its normal

connection with the rest of the foot. These dislocations are almost invariably connected with fracture of the lower end of the fibula, or of the inner malleolus. In fact, on looking at the arched cavity into which the astragalus is received, it is evident that this bone can scarcely be displaced laterally without fracture of one side of this arch. In considering these dislocations we must, in accordance with the general nomenclature of similar accidents, in which the distal part is always said to be displaced from the proximal, look upon the foot as being dislocated from the leg, and not consider the tibia as being displaced upon the foot. It is necessary to explain this, inasmuch as a good deal of ambiguity occurs in surgical writings from the same accident being described differently, according to the view taken of the part displaced. Thus, Astley Cooper speaks of the tibia as being dislocated at the ankle; whilst Boyer and others, regarding the foot as the part displaced, have described the same injury in directly opposite terms.

Dislocations of the foot from the bones of the leg may take place in four directions viz., *to either side*, *backwards*, or *forwards*. In all cases, the injury appears to be occasioned either by the foot being twisted under the patient in jumping or running; or else by its being suddenly arrested by coming into contact with the ground whilst the body is carried forwards. The lateral dislocations when simple are almost invariably incomplete, although rare cases have been recorded in which they were complete. Compound lateral dislocations, the result of extreme violence, are not uncommonly complete. The simple antero-posterior dislocations are more commonly complete.

The incomplete dislocation **Outwards** is of most frequent occurrence. The inner malleolus projects forcibly against the skin. The deltoid ligament is either ruptured, or the lower end of the inner malleolus broken off; there is a depression above the outer ankle corresponding to a fracture of the fibula; and the sole of the foot is turned upwards and outwards, the inner side touching the ground, whilst the outer edge is turned up. It is, in fact, merely a severe case of Pott's fracture (Fig. 235).

In the dislocation **Inwards**, which is a rare accident, the lower end of the tibia is splintered off in an oblique manner from within outwards, whilst the external lateral ligament is ruptured or the fibula broken. The outer edge of the sole rests against the ground, and the inner side is turned up. The astragalus is thus rotated on its longitudinal axis in such a way that the inner articular surface is in contact with the lower end of the tibia.

The *Reduction* of these lateral displacements is readily effected by traction on the foot, while the leg is flexed at the knee in order to relax the muscles of the calf; leg splints with lateral foot-pieces must then be put on, or Dupuytren's splint may be applied on the side opposite to that to which the foot is displaced.

In the dislocation of the foot **Backwards**, the deltoid ligament is ruptured, the fibula probably broken in the usual situation, and the tibia rests on the scaphoid and cuneiform bones; the foot consequently appears shortened, the heel rendered more projecting, and the toes pointing downwards.

Partial dislocation in this direction may occur without fracture, as the following case will show. A boy, aged about 14, wrestling with another felt his left foot give way and fell. He was unable to stand, and was at once brought to University College Hospital. Two hours afterwards there was no swelling about the ankle. The sole looked directly downwards, but the foot

was twisted outwards on the vertical axis of the astragalus for about 15°. The lower end of the tibia formed a distinct projection, most marked on the outer side. Beneath this was a corresponding hollow. The heel was thrown slightly backwards. Measured with a pair of calipers the distance from the tendo Achillis to the instep was increased by half an inch. The great toe was over-extended by the stretching of the extensor tendon and could not be flexed. The movements of the ankle were very limited. There was no fracture of either bone. Reduction was easily effected under chloroform.

The dislocation **Forwards**, in which the foot is lengthened, and the tibia rests upon the upper and posterior surface of the os calcis, behind the astragalus, is an accident of extreme rarity.

In the *Treatment* of these antero-posterior displacements of the ankle, traction of the foot in a proper direction, the leg being fixed and flexed upon the thigh, will readily effect replacement. Sometimes subcutaneous division of the tendo Achillis is necessary. The limb should afterwards be put up in a plaster of Paris or starched bandage for at least three weeks.

Compound Dislocations of the Ankle-joint are serious and by no means unfrequent accidents, the displacement occurring in the same direction and from the same causes as the simple forms of the injury.

In the *Treatment* of compound dislocations of the ankle an attempt should be made to save the limb in all cases in which the main vessels are sound, the soft parts not too extensively torn or the bones too widely splintered. Some efficient antiseptic method must be adopted and a successful result will usually be obtained. The limb should be firmly fixed to a single splint with a rectangular footpiece applied to the side opposite to the wound. If the bones are projecting and comminuted it may be necessary to remove the splinters, and possibly to saw off the malleoli in order to obtain a flat surface to rest on the astragalus, as was originally recommended by Hey. If antiseptic treatment is not available an attempt may still be made to save the limb if the soft parts be not too extensively injured. Astley Cooper, who was a strong advocate of conservative treatment in these cases, advised that the wound should be closed by means of a piece of lint soaked in the blood flowing from the wound. Should suppuration occur, the pus usually burrows widely beneath the muscles of the calf and secondary amputation may be necessary.

Dislocations of the Astragalus.—The astragalus is occasionally displaced from its connection with the bones of the leg above, and with those of the tarsus below, being thrown either *forwards* or *backwards*. These dislocations invariably happen from falls upon or twists of the foot; more particularly when it is extended upon the leg. When the foot is in this position, the lower end of the tibia either breaks off on the application of sufficient violence, or the head of the astragalus is forced out of the cavity of the scaphoid and its bed on the os calcis; the particular kind of displacement that occurs depending upon the direction in which the force is acting and in which the foot is twisted. Dislocation of the astragalus differs from dislocation of the foot in this, that when the foot is dislocated, the astragalus, though thrown out from under the malleolar arch, preserves its connections with the rest of the tarsus; whilst these are always broken through when the astragalus is the bone dislocated, even though it have not completely escaped from between the malleoli.

In the dislocation **Forwards**, the head of the bone may be thrown either

outwards or *inwards*, very seldom directly to the front; but I do not think there is any evidence to show that complete lateral dislocation of this bone can occur irrespective of displacement forwards; the so-called *lateral* dislocations being displacements of the bone forwards, with twists to one or the other side. The dislocation *forwards*, with lateral inclination, may be either *complete* or *incomplete*. When it is *complete*, the bone is thrown out of its bed on the calcaneum, and separated from its connections with the malleolar arch above and the scaphoid anteriorly, being forced in front of the tarsus, and lying upon the scaphoid and cuneiform bones. When the dislocation is *incomplete*, the head is separated from the scaphoid, and is thrown up on it, or on the external cuneiform or cuboid bones, the body of the astragalus maintaining its connections with the malleolar arch and os calcis. I agree with those who describe the displacement *forwards* and *outwards* as more common than that *forwards* and *inwards*.

In either case the displaced bone forms a distinct tumour upon the instep, in the outline of which the form of the astragalus can be distinctly made out. Over this, the skin is so tightly drawn as often to appear to be on the point of bursting. When the bone is thrown somewhat inwards, the foot is turned outwards, and the internal malleolus projects distinctly. When the astragalus is thrown *outwards*, displacement of the foot inwards, with great projection of the lower end of the fibula, takes place. In some cases, fracture of the neck of the astragalus is combined with these dislocations; and not uncommonly the luxation is compound from the first, or speedily becomes so if left unreduced, in consequence of the sloughing of the skin which covers the anterior surface of the bone, the exposed portion of which undergoes necrosis.

The dislocation **Backwards**, into the hollow between the tendo Achillis and the tibia, is rare, there being, according to Hamilton, but twenty recorded cases. This form is, I believe, always complete, and in the majority of cases there is displacement of the bone *inwards*, as well as backwards.

Treatment.—The reduction of the dislocation *forwards*, whether attended with lateral displacement or not, varies greatly in facility; in some instances being effected with the greatest possible ease, in others being attended with almost insurmountable difficulties. This difference depends, I think, on whether the dislocation is complete or not. When the astragalus is not completely thrown from under the arch formed by the bones of the leg, a portion of it being still entangled between their articular surfaces and that of the calcaneum, it may usually be readily reduced by relaxing the muscles of the calf, and pushing the bone back into its proper position. But when the astragalus is completely dislocated, the upper surface of the calcaneum is drawn up under the arch of the malleoli by all the strength of the muscles that pass from the leg to be inserted into the foot. In these circumstances, in order that reduction may take place, it is necessary first of all to separate the articular surfaces to such an extent as to admit of the astragalus being pushed back into its socket; this is almost impossible, owing to the great perpendicular thickness of this bone, to the extent to which it is consequently necessary to draw down the foot, and to the little purchase that can be obtained on it. In such cases, reduction has been greatly facilitated by the division of the tendo Achillis, by which simple operation the whole strain of the muscles of the calf is taken off.

If reduction be still impracticable, and the bone continue irreducible on the dorsum of the foot, what should be done? Two courses present them-

selves to the Surgeon: either at once to cut down upon the astragalus and to remove it; or to put the limb at rest on a splint, and to wait the result. In some rare cases, the displaced astragalus has given rise to comparatively little inconvenience; but this can seldom be expected. If the dislocation have been in the direction forwards, the skin will usually slough and the displaced bone then will necrose and must be removed. In former times it was considered safer to leave the bone as long as possible before removal in the hope that the space between the tibia and the os calcis might have closed behind the displaced astragalus before it had to be taken away and that the operation would thus be reduced to a simple superficial incision. In the present day, with efficient antiseptic treatment, there is no fear of any trouble following immediate removal. If, therefore, the means for carrying out the treatment are at hand, the bone should at once be dissected out and the case treated like one of excision of the astragalus for disease.

In luxation *backwards*, the bone has not hitherto to my knowledge been reduced, except in one case which occurred in University College Hospital, in which the tibia and fibula were also fractured. It is by no means improbable that subcutaneous division of the tendo Achillis may in future

Fig. 289.—Dissection of Foot in Compound Dislocation of Astragalus outwards.

enable the Surgeon to effect reduction. The result is, however, satisfactory, even though the bone be not reduced, the patient recovering with a useful foot. If the dislocation be left unreduced, the soft parts covering the bone may slough, as happened in a case recorded by R. C. Williams of Dublin, in which the bone was consequently extracted.

In **Compound Dislocation of the Astragalus** (Fig. 289), the rule of practice must depend upon the extent of injury. If the integuments have merely been rent in consequence of the outward pressure of the displaced bone an attempt must be made to reduce the dislocation by the aid, if necessary, of the division of the tendo Achillis; and, if this be effected, to close the wound by the first intention. If the bone be comminuted as well as dislocated, the proper practice will be to remove the loosened fragments, and to dress the wound antiseptically, allowing it to heal by granulation. If the bone be irreducible, it should at once be dissected out. If together with the dislocation of the astragalus, the foot be extensively crushed, amputation may be required either at the ankle-joint or at some convenient part of the leg.

Subastragalar Dislocation.—In this injury, which is produced by causes similar to those occasioning dislocation of the astragalus, the calcaneum and

scaphoid, carrying with them the rest of the foot, are dislocated from the astragalus, which is left *in situ* under the malleolar arch. The displacement is most commonly in a direction *backwards*, with an inclination inwards or outwards. In these cases the nature of the injury is recognized by the backward displacement of the heel, whilst the astragalus retains its normal relations to the malleoli. The *Treatment* consists in flexion of the leg and attempts at reduction by extension applied to the foot in a direction forwards. If moderate extension fail, division of the tendo Achillis, and if necessary of other tendons, may be practised, on the same principle as in dislocation of the astragalus.

Dislocations of the other Tarsal Bones are of extremely rare occurrence. Most of these bones, however, have been found luxated at times.

The **Calcaneum** has been dislocated laterally from its connection with the cuboid in consequence of falls from a height, the sufferer alighting upon his heel. Chelius mentions a case in which this bone was dislocated by the effort of drawing off a tight boot. *Reduction* seems to be readily effected by relaxing the muscles, and pressing the bone back into its proper position.

The **Scaphoid** and **Cuboid Bones** have been dislocated upwards, in consequence of a person jumping from a height and alighting upon the ball of the foot. In these instances the limb is shortened and curiously distorted, the toes pointing downwards, and the arch of the instep being increased so as to resemble closely enough the deformity of club-foot. *Reduction* may be effected by drawing and pressing the parts into position.

The **Internal Cuneiform Bone** has occasionally been found to be dislocated. Astley Cooper mentions an instance of the kind. If reduction be not effected by pressing the bone into its position, no great evil appears to result to the patient, the motions of the limb not being seriously interfered with.

Sometimes the tarsal joints are extensively torn open without any one bone being distinctly dislocated. I have seen this accident in the case of a young man who caught his foot between the spokes of a revolving wheel; the foot was violently bent and twisted, and all the tarsal joints more or less torn open, so as to necessitate amputation.

Dislocation of the Metatarsal Bones, though excessively rare from the manner in which they are locked into the tarsus, and retained by short and strong ligaments, yet occasionally occurs. Instances are recorded by Dupuytren and Smith; Liston mentions a case of luxation of the metatarsal bone of the great toe from direct violence; and Tuffnell records a case of luxation downwards and backwards of the inner three metatarsal bones, in a man whose horse fell and rolled over him. Two cases have occurred in my practice, in one of which, by the pressure of a "turn-table" on a railway, the *outer* three metatarsal bones were dislocated downwards. In the other, in consequence of a horse falling and rolling on its rider, there was a compound dislocation of the first, with a simple dislocation of the fourth, metatarsal bone. The question of amputation will always present itself in these cases, and must be determined on general principles, by the age of the patient, and the extent of injury to the soft parts.

Luxations of the *Phalanges of the Toes* but rarely happen, and present nothing special in nature or treatment.

INJURIES OF REGIONS.

CHAPTER XXIV.

INJURIES OF THE HEAD.

INJURIES of the Head are among the most important subjects that can engage the Surgeon's attention. Their importance is derived not so much from the injury of the scalp and skull, as from the implication of the brain in many cases directly, and in others indirectly and remotely. In consequence of this, it is of the first moment in practice to study these injuries as a whole, with special regard to the affections of the encephalon that are produced by them, and from which they derive the greater part of their interest.

INJURIES OF THE SCALP.

CONTUSIONS OF THE SCALP are of common occurrence, and present some peculiarities. However severe the contusion may be, the scalp seldom sloughs. This is owing to the great vascularity and consequent vitality of the integuments. In many cases, the contusion is followed by considerable extravasation of blood, raising up the scalp into a soft semi-fluctuating tumour. It occasionally happens, that this extravasation gives rise to the supposition that fracture exists, owing to the edge of the contusion feeling hard, whilst the centre is soft, causing an apparent depression of the subjacent bone. In some cases, indeed, this deceptive feeling will occur without any considerable extravasation of blood, the depressed centre being due to the compression of the scalp by the blow that has been inflicted upon it. This I have seen occasionally in children, in whom the scalp is soft. The difficulty of distinguishing between such an extravasation and a depression of bone is often so great as to mislead the most experienced Surgeons. Usually it can be effected by feeling the smooth bone at the bottom of the soft central depression. If seen soon after the accident the raised edge can usually be made to melt away under the finger by firm pressure, till the solid bone can be clearly felt beneath, at the same level as that in the centre of the swelling. But in case of doubt, if symptoms of compression of the brain are present, it will be safer to make an incision, and examine directly the state of the bone itself.

The **Treatment** of contusion of the scalp is very simple; the continuous application of evaporating lotions being usually sufficient for the removal of all effusion. As a rule no attempt should be made to remove the blood by puncturing the swelling, but if the amount is considerable, and more especially if it coagulates at the circumference, leaving a collection of fluid in the centre,

this may be removed by means of the aspirator. Contusions of the scalp in young women have been followed by severe neuralgic pains in the part struck which are extremely rebellious to treatment; but in two cases which I have seen, after lasting for a long time, they gradually disappeared. In such cases, incisions down to the bone are said to have been beneficial.

CEPHALHÆMATOMA.—It occasionally happens that bloody tumours of the scalp form in newly-born children, either from contusion of the head in consequence of the pressure to which it is subjected in its passage; or from bruising by obstetric instruments. These tumours, which are often large and fluctuating, are termed **cephalhæmatomata.** They may occur in two situations, either *between the aponeurotic structures of the scalp and the periosteum*, or *between this membrane and the bone.*

The **Subaponeurotic Cephalhæmatoma** is by far the most common variety. It usually forms a large, soft, fluctuating tumour, situated upon one of the parietal eminences, and having a somewhat indurated circumference. The tumour will usually subside in a few days under the use of a simple evaporating lotion.

The **Subperiosteal** or **Subpericranial Cephalhæmatoma** is an injury of somewhat rare occurrence. It appears as a fluctuating tumour, almost invariably seated on one parietal bone, most commonly the right, without discoloration of the scalp, but with a hard elevated circle around it, and a soft depressed centre, almost giving the sensation of a hole in the cranium. Pressure, however, gives rise to no cerebral symptoms, and enables the Surgeon to feel the bone at the bottom of the depression. These tumours are usually small, seldom more than two inches in diameter, and it occasionally happens that they are multiple. It is worthy of note, however, that each tumour is always confined to a separate bone, never passing beyond the sutures, where the adhesions between the periosteum and the bone are strongest. This affection is most frequently met with in children born in first confinements, and owing to the greater size of the head it is more common in boys than in girls; according to Bouchard, in the proportion of thirty-four to nine.

Pathology.—In this affection the periosteum is separated from the bone by an extravasation of blood, and both are covered with decolorised clot, but are otherwise healthy; the fluid in the centre is the serum from the coagulated blood. The hard circle surrounding the depression is formed by a deposit of osseous tissue in the angle formed by the raised periosteum and the bone beneath. This deposit is effected in such a way that, on a transverse section being made, the inner wall is found nearly perpendicular, whilst the outer slopes down upon the cranium, thus giving a crateriform appearance to the margin of the tumour.

Treatment.—In the majority of cases the blood is slowly absorbed and no treatment is required. If, however, absorption do not occur, aspiration will usually effect a cure. If it fails, the swelling must be punctured and a fine drainage-tube inserted with proper antiseptic precautions. If suppuration occurs, there is some risk of necrosis of the bone and intracranial mischief.

WOUNDS OF THE SCALP are often followed by serious consequences. They are divided into three classes—first, those not penetrating to the pericranial aponeurosis; secondly, those opening up the loose areolar tissue beneath that membrane without exposing the bone; and thirdly, those extending through the periosteum and denuding the bone. Scalp wounds are very common as

the result of drunken brawls or accidents amongst the lowest classes, and the heads on which they are inflicted are very often grimed with dirt and crusted with grease, while the patients are often broken down by dissipation and improper feeding. It is not surprising, therefore, that unless great care is taken in the treatment, erysipelas and other diffuse inflammations are very prone to follow these injuries. If these disturbing causes are absent scalp wounds usually heal with remarkable ease, even though the part be much bruised and lacerated, and sloughing rarely occurs, as the supply of blood is abundant and the vitality of the tissues high.

The *Complications* which may follow wounds of the scalp vary with the degree of the injury. In the first class, in which the pericranial aponeurosis is not wounded, no complications occur beyond those common to all similar injuries. In the second class, in which the pericranial aponeurosis is wounded, diffuse suppuration beneath that membrane is very prone to occur if strict asepsis be not maintained.

The pericranial aponeurosis or tendon of the occipito-frontalis muscle is firmly attached to the fat and fascia superficial to it, whilst it is very loosely connected with the parts underneath. This arrangement is often of great service in protecting the skull from fracture, especially when the head is caught between two solid bodies, as, for example, the wheel of a cart and the ground; the scalp is then torn off and the head slips away, thus escaping further injury. In suppuration occurring under the tendon of the occipito-frontalis, the pus gravitates to the most dependent parts until arrested by the attachments of the aponeurosis. These attachments are as follows:—Posteriorly, the fleshy bellies and tendon are attached to the superior curved line of the occipital bone, and to the mastoid process along the line of insertion of the sterno-mastoid. Laterally, the aponeurosis is thin, gives origin to the attollens and attrahens aurem, and in front of the ear runs down, superficial to the temporal fascia, to be attached, like it, to the zygoma; pus gravitating in this direction, therefore, forms a bag of fluid just above the zygoma, never extending into the cheek. In front, the fleshy fibres of the muscle are blended with those of the corrugator supercilii and the orbicularis palpebrarum, while in the middle line they are continued down over the nose into those of the pyramidalis nasi; the pus under this part will therefore collect in the upper eyelids, and in a pouch over the root of the nose.

When the wound is too tightly closed, either by sutures or by a pad of lint allowed to stick to it by the dried blood, the serous fluid, necessarily effused in the first few hours, forces its way into the loose areolar tissue beneath the pericranial aponeurosis. If the wound be small the fluid is usually absorbed, and healing takes place without trouble. Frequently, however, it distends the lymph-spaces and decomposes, and thus starts a spreading inflammation which may affect the whole of the subaponeurotic areolar tissue. This septic cellulitis commences usually about the third day after the injury, and terminates, as such inflammations generally do, in diffuse suppuration and sloughing of the cellular tissue. The scalp itself never sloughs, nor is the bone exposed by destruction of its periosteum. There is a general puffy swelling of the scalp and diffused redness, often extending over the face, and it is probable that this state of things has often been confounded with erysipelas, and has given rise to the idea that stitches in the scalp cause that disease. This condition is frequently fatal, especially in old people, unless

actively and efficiently treated; death occurring either from septic poisoning, pyæmia, or exhaustion.

It is important to make the diagnosis between erysipelas of the scalp and diffuse suppuration beneath the pericranial aponeurosis, as the treatment of the two conditions is very different. In *erysipelas* there is a characteristic invasion (see Chap. XXXII.); the redness and swelling, when they appear on the face, can be seen to have a sharply defined margin, and they speedily extend beyond the limits of the pericranial aponeurosis, reaching to the cheeks or mouth, and very commonly involving the pinna of the ear. The lymphatic glands at the upper part of the neck are swollen and tender. In *diffuse cellulitis beneath the aponeurosis*, the swelling does not go beyond the limits of that membrane; the blush that may extend beyond is of small extent, and has a diffused margin; the pinna of the ear is not affected, and the lymphatic glands are not swollen.

In the first and second classes of scalp wounds there is no special tendency to cerebral complications of any kind when the brain is not injured by the same violence that inflicts the wound.

In the third class of scalp wounds in which the bone is exposed, and perhaps denuded for some extent, healing as a rule takes place readily enough if drainage is maintained and asepsis secured. Should a part of the injured scalp be torn away or slough, and a portion of the skull be exposed, exfoliation of the outer table, though probable, does not necessarily occur; for in many cases granulations will spring up on the exposed bone, which still receives vascular supply from the diploë, and thus healing will take place.

If decomposition of the discharges and suppuration occur in a wound laying bare the bone, the patient is exposed to various dangers beyond diffuse suppuration beneath the aponeurosis. The bare bone, being bathed in septic pus, is not unlikely to necrose. Should this happen, the dead portion separates in most cases without further evil consequences, but until this has taken place the patient can never be considered out of danger. The complications to which he is liable are caused by the septic matter penetrating the dead outer table and affecting deeper parts. In this way a diffuse septic inflammation may be set up in the diploë (septic osteomyelitis), and should this happen death from septicæmia or pyæmia is almost inevitable. After death in such a case, on chiselling away the outer table, the diploë will be found to be soaked in offensive pus, and the large veins that lie in it will be seen to contain softening thrombi, portions of which have been washed on into the blood stream and given rise to abscesses in the lungs or other viscera. All forms of pyæmia and septicæmia are met with in these cases, and the symptoms differ in no respect from those which occur in blood-poisoning from other wounds. (See Chapter XXXIII.) The older writers on Surgery had noted and had marvelled at the strange phenomenon of hepatic abscesses following slight head injuries, but had generally overlooked the occurrence of secondary deposits in other organs and structures. There is, however, no reason to believe that hepatic abscesses are more common in pyæmia after head injuries than in that arising from any other injury. In eighteen cases Prescott Hewett found the lungs studded with abscesses in thirteen, and the liver in three; and of these three, in one case only was the liver alone affected.

The second great complication of scalp wounds exposing the bone is *intra-cranial suppuration.* It may occur with diffuse septic inflammation of the

diploë, but is more frequently met with independently of this. The pus may be situated immediately beneath the injured bone superficial to the dura mater, on the surface of the brain beneath the dura mater, or more deeply in the cerebral substance. The symptoms and treatment of this complication will be more conveniently considered with intracranial suppuration in general (p. 774 *et seq.*)

Treatment of Scalp Wounds.—From what has already been said it will be evident, that in cases of wound of the scalp not complicated by injury to the brain, the essentials of treatment are to avoid retention of the discharges and to prevent their putrefaction. In all cases the parts around the wound must be shaved for a sufficient distance. The wound may then be plugged with a piece of sponge soaked in some efficient antiseptic fluid, carbolic acid lotion (1 in 20), or perchloride of mercury (1 in 1,000) being the best, while the scalp around it and the remaining hair are washed with hot water and soap, or sponged with a weak solution of ammonia, and afterwards thoroughly soaked in the antiseptic fluid. If there be arterial hæmorrhage it may, if slight in amount, be arrested by the pressure of the dressing, the firm bone beneath affording excellent counter-pressure. Should the bleeding be more free, the vessels must be secured by ligature or torsion. In doing this some trouble may be caused by the density of the tissues in which the vessels are lying. Should other means fail, or not be at hand, a pin may be passed beneath the artery, and compression made over it by a figure-of-8 suture. The scalp having been cleaned, and the bleeding stopped, the wound itself may again be thoroughly cleansed with the antiseptic lotion and its edges brought together. In doing this, strapping should not be used. It seldom adheres well on the scalp, and tends to shut in the discharges. In small wounds, as the rigid tissues of the scalp have little tendency to gape, the mere pressure of the dressing will bring the edges in contact. In larger wounds, silk, horse-hair, or silver-wire sutures may be inserted. The use of sutures has been deprecated by many Surgeons in injuries of the scalp, as tending to favour erysipelas; undoubtedly, much mischief will arise if the wound be stitched up too closely and septic matter accumulate in it, and in small wounds sutures are generally unnecessary, but in extensive lacerations they cannot be dispensed with. In the majority of cases, dry dressings will be found most efficient. The wound may be sprinkled with iodoform, and a large pad of iodoform wool, salicylic wool or silk, sal alembroth gauze or wool, or some other dry absorbent antiseptic preparation, may be applied, and secured with a bandage, so to exert a moderately firm elastic pressure and to retain the separated parts in apposition and at perfect rest, while at the same time the accumulation of discharges is prevented. Drainage-tubes are seldom required if too many stitches be not put in. Such a dressing may frequently be left untouched for a week or ten days, at the end of which time union will be perfect. The indications for removing it earlier are a smell of putrefaction, a rise of temperature, pain, or a puffy swelling of the scalp beyond the dressing. The patient should be freely purged, and kept at rest on a rather low diet: any cerebral symptoms that occur being treated in accordance with the principles laid down in discussing traumatic affections of the brain. In this way, union will very probably take place through the greater portion of the injured surface; should it not do so, however, or should any part slough, granulations spring up, and repair goes on with surprising rapidity.

It frequently happens that the scalp is bruised and lacerated as well as wounded: and very commonly a large flap of integument is stripped off the skull, and is thrown down over the face or ear. In these cases, advantage is taken of the great vitality of the scalp. However extensively lacerated this may be, however much it may be begrimed with dirt, it is a golden rule in surgery not to cut any portion of it away, but, after shaving the head and ligaturing any bleeding vessels, to clean it thoroughly, and replace the flap in its proper position.

Should suppuration occur beneath the pericranial aponeurosis in consequence of the antiseptic treatment having failed, and the wound being too tightly closed, active and efficient treatment is necessary to save the patient from the dangers of septicæmia or pyæmia. As soon as pain, with some swelling round the wound and elevation of temperature, raises a suspicion that diffuse inflammation is spreading from the wound, all dressings should be removed. It will frequently be found that the edges of the wound are adhering to each other; if this be the case, they must be separated with a director, when a small quantity of thin offensive pus frequently escapes. A fomentation of boric acid lint or salicylic wool may then be applied, and covered over with oil-silk, and over this a sheet of cotton wool and a bandage. This must be changed about every four hours. In most cases this treatment will be successful in arresting the unhealthy inflammation, but should it fail and the cellulitis extend more widely, it will be necessary to make free incisions, reaching through the pericranial aponeurosis wherever the inflammation has extended. Before doing this the head must be completely shaved, without which cleanliness is impossible. It is more essential that this should be done in women even than in men, however much they may object, as their hair is longer. The incisions should be each about one inch in length, and should vary in number according to the extent of the mischief. They must be carefully planned so as to avoid the main arteries (Fig. 290). After bleeding has been arrested hot dressings must be applied as before described.

Fig. 290.—Head showing Lines for Incisions in Diffuse Cellulitis beneath the Pericranial Aponeurosis.

Simple erysipelas after a scalp wound presents nothing special in its treatment.

When the skull itself is extensively denuded in consequence of the pericranium being stripped off the subjacent bone together with a flap of the scalp, it does not necessarily follow that necrosis and exfoliation of the exposed bone will occur. The flap must be laid down on the denuded osseous surface, to which it may possibly contract adhesion through the medium of granulations.

The treatment of intracranial suppuration will be considered later on (p. 774).

INJURIES OF THE SKULL.

These possess great interest, not so much from the lesion of the bone itself, as from its frequent complication with injury of the brain and its membranes.

This cerebral complication may either be produced by direct injury, the fragments of the fractured bone compressing or wounding the brain; or it may be the result of concussion or laceration of the brain by the same violence that causes the fracture.

Bending-in of the Cranial Bones without Fracture is an accident that may occur in infants and young children, before the bones of the skull are completely ossified. In several instances, the displaced bone has been raised by aspiration with an india-rubber sucker. But no harm comes of leaving the bone depressed, as it will generally recover its proper level in time.

Contusion of the Cranial Bones without fracture, occasioned either by ordinary direct violence or by the oblique impact of bullets, is a very serious injury, more particularly when complicated with wound of the scalp. In it there are four sources of danger, any one of which may be followed by a fatal result; viz.: 1. Necrosis of the part of the bone struck, leading to exfoliation of the outer table, or to separation of the whole thickness of the cranium and exposure of the dura mater; 2. Suppuration under the bone, between it and the dura mater; 3. Pyæmia with secondary visceral abscesses, consequent on suppuration of the diploë around the necrosed point of bone, and septic thrombosis of the cranial veins,—a condition to which reference has already been made; and, 4. Laceration of the brain immediately beneath the point struck, or at the corresponding spot on the opposite side of the brain. The former condition occurs only when the blow is very violent, sudden, and limited to a small area, as when the skull is grazed by a bullet. Under other circumstances the chief laceration is always on the opposite side of the brain.

The following statement, taken from the records of the War Department of the United States army, gives a good summary of the results of gunshot contusions of the skull without fracture, or, at any rate, in which the fracture was limited to the inner table. In many of these there was without doubt some superficial laceration or bruising of the brain.

Of 328 cases, 55 died, 173 were disabled, 100 recovered. The deaths arose from hæmorrhage, 2; tetanus, 4; pyæmia, 4; dysentery and fever, 8; compression from blood or pus, 17; various intracranial injuries, 20. These injuries appeared to be most dangerous in the temporal and frontal regions, and least so in the occipital.

Amongst the 173 disabled, the following complications are specified as the causes of the disability:—

Persistent pain in the head, 10; paralysis of limbs, more or less marked, 23; impairment of vision, 16 (wounds mostly in the frontal region); impairment of hearing, 14 (wounds mostly in parietal and temporal regions, but some frontal and some occipital); epilepsy, 9; insanity, 10. Vertigo, giddiness, and dizziness were some of the commonest complaints among pensioners.

Fractures of the Skull are invariably the result of external violence. This may act *directly* in breaking and splintering the part struck, the fissures often extending to a considerable distance and detaching large portions of the skull; or the violence may act in an *indirect* manner, producing the fracture either without being applied immediately to the cranium, or else at an opposite part of the skull to that which is struck. Thus the base of the skull may be fractured by the shock communicated to it when a person, falling from a height, strikes the ground heavily with his feet. A somewhat doubtful variety of indirect fracture in which the lesion occurs at a point of the skull

opposite to that which has been struck has received the name of Fracture by Contrecoup.

Fracture by Contrecoup has been described by some Surgeons as of frequent occurrence, whilst it has been denied by others. Aran laid down as an absolute rule that all fissured fractures without exception start from the point in the skull to which the violence has been applied. Every hospital Surgeon must, however, occasionally have met with fissures, especially in the thin parts of the base of the skull, which could not be traced to the point in the vault which directly received the injury, though such cases are undoubtedly rare. Moreover, it must not be concluded at once that such fissures are the result of *contrecoup*. A man may receive a violent blow on the frontal bone, wounding the scalp, and the fracture may be found in the occipital region. In such a case, it often happens that the fissure was really caused by a blow on the back of the head received in falling. In other cases in which the patient falls directly on the vertex and fractures the base of the skull, the fracture is often caused by the weight of the body communicated through the vertebral column to the condyles of the occipital bone. It has been shown experimentally by C. Bell, Bruns, and Félizet, that the skull possesses a considerable degree of elasticity, and that when a violent force, such as a blow acting on a considerable extent of the surface, or powerful pressure is applied to it, it undergoes an alteration in shape not merely at the point struck, but as a whole. There is a shortening of the diameter corresponding to the direction of the force, with lengthening of the other diameters. Thus, a force applied to the vertex tends to shorten the vertical diameter, and to cause a corresponding lengthening of the antero-posterior and transverse diameters. A skull in this way squeezed out of shape may yield at the weakest part, and a fissure may thus be formed at a point remote from that to which the force was applied, although much more commonly the blow determines the starting point of the fissure. That the fissures in a fractured skull may actually gape at the moment, and close again as soon as the force ceases to act, is occasionally proved by the presence of foreign bodies tightly grasped in them. Thus, hairs have been found firmly held in the crack, and Hoffmann records a case in which a fold of dura mater was nipped in a fissured fracture. The rending force thus exerted by the compression of the skull in one direction and its elongation in another, explains more readily than any other theory the distance to which a fissure often extends, and the way in which it frequently follows for a certain distance along the line of a suture, entering the solid bone again when the suture comes to an end, and also the fact that a foramen, even the foramen magnum, offers no impediment to the extension of the fracture.

In certain cases the thin orbital plates of the frontal bone have been found to be fissured after violent blows on the back of the head, and in these it has been suggested that the fractures resulted from the impact of the brain substance driven against the bone by the force of the blow.

If all these different forms of fracture be excluded, but little is left that needs the theory of *contrecoup* for its explanation.

Although, therefore, Aran's rule, that all fissures radiate from the point struck, is not absolutely accurate, yet it is so nearly true that it forms the best guide we have to the course of a fracture. Thus, if we have clear evidence that a man has received a blow on the parietal eminence and he has profuse bleeding from the nose, we may reasonably conclude that the fracture roughly

corresponds to a line drawn from the point struck to the cribriform plate. In a case under my care in University College Hospital the patient had received a violent blow, not causing a wound, on the right occipital region, and was bleeding freely from the left ear. Soon after admission the respiration became greatly embarrassed without any signs of general compression of the brain. Following Aran's rule, the diagnosis made was, that a fissured fracture crossed the foramen magnum, and that extravasated blood was pressing on the medulla oblongata; a conclusion which was confirmed by the *post-mortem* examination.

FISSURED FRACTURE.—An ordinary **undepressed fracture** of the skull consists in a fissure, sometimes single, at other times starred, extending often to a considerable distance through the bones, radiating sometimes across the skull, and in other cases completely detaching its upper from its lower part, or its anterior from its posterior segment. In some cases the fracture extends into one of the sutures; and in other instances, which, however, are very rare, the sutures are separated without any fracture.

A fissured fracture usually results from direct violence, but is also the only form of fracture that can be supposed to arise by *contrecoup*. A fissure gives rise to no signs by which its diagnosis can be effected, and often escapes detection altogether, more particularly when the scalp covering it is not wounded; or when so large a quantity of blood is extravasated as to render it impossible for the Surgeon to feel the subjacent bone. If, however, the scalp covering the injured bone have been wounded, the existence of a fracture may be ascertained by running the finger-nail, or the end of a probe, over the exposed surface of the bone, or by seeing a fissure which remains filled with blood after wiping the surface, or from which blood may be freely oozing.

As the whole importance and danger of fracture of the skull depend, not upon the injury that the bone has sustained, but on the concomitant or secondary lesions of which the contents of the cranium may be the seat, no special *Treatment* is required for the fracture itself when simple and undepressed, the Surgeon's whole attention being directed to the injury that may have been inflicted on the brain or scalp. Should the fracture be compound the patient's head must be completely shaved and cleaned as before described (p. 719), and the wound should then be carefully cleansed with carbolic lotion (1 in 20), or perchloride of mercury (1 in 1000), and some efficient antiseptic dressing applied (p. 720). The patient's safety depends to a great extent upon the prevention of decomposition. In all fissured fractures there is necessarily some blood extravasated between the dura mater and the bone, as well as in the diploë, supposing the fracture to be in a part where this exists. If this extravasated blood should decompose, the patient would run all the dangers of suppuration between the dura mater and bone or septic inflammation of the diploë. Moreover, it is always possible that the dura mater may be torn even beneath a simple fissure, though fortunately this is rare. Should this, however, have taken place, and decomposition of the discharges occur, the danger of septic meningitis setting in is very great; and should this happen, the death of the patient is a certain consequence.

Although the most important precautionary measures for guarding against inflammation of the brain and its membranes are doubtless those intended to prevent septic processes in the wound, yet other measures should on no account be neglected. The head should be shaved if this has not already been done in dressing the wound, and cold may be applied. This can easily be done

over the carbolic gauze dressing or over the carbolic oil, but it can hardly be efficiently employed over iodoform or salicylic wool; and this, perhaps, in some cases forms an objection to their use. Care must always be taken not to soak the dressing with water oozing through a half-putrid bladder; the india-rubber ice-cap should be used when possible, or if that be not at hand a common sponge-bag will answer the purpose fairly well. The bowels should be well opened, and the room kept cool and quiet. Should any symptoms of inflammation of the brain make their appearance, free, and if need be, repeated bleeding is, perhaps, of more service than any other means, and should never be omitted, except in feeble, very young, or aged subjects.

Simple fissured fractures of the vault of the skull in infants and young children are, in rare cases, followed by the formation of a fluctuating tumour under the scalp containing cerebro-spinal fluid. Such cases have been recorded by W. Haward, R. C. Lucas, T. Smith, R. J. Godlee and others, and P. S. Conner has suggested the name of **Traumatic Cephalhydrocele** for the condition. The tumour becomes tense when the child cries, and can be slightly diminished by pressure, but not without causing some signs of cerebral disturbance. In most cases it pulsates distinctly, synchronously with the heart. The tumour has usually appeared soon after the injury, and has often been mistaken at first for a cephalhæmatoma. According to Conner about half the recorded cases have recovered, but the patients have been left with more or less marked irritability of temper or other signs of cerebral mischief. The remainder died sooner or later, usually with symptoms of meningitis. In a few cases the child has been the subject of chronic hydrocephalus, although in this condition the thinned and expanded cranial bones being at the same time preternaturally elastic and mobile, are seldom fractured. In one case however that was under my care, a hydrocephalic child fell from the top of a house on to its head, and sustained a long fracture through the left side of the skull, but without any scalp wound. Shortly after the accident, a large soft fluctuating tumour formed under the scalp opposite the line of fracture; and, on this being tapped, about three ounces of cerebro-spinal fluid were drawn off. This operation was repeated, but the child died about ten days after the injury, with hemiplegia of the opposite side, and convulsions.

In the fatal cases a fissured fracture has been found most commonly in the parietal, temporal and frontal regions. In several the fracture was gaping to the extent of half an inch or more, and in these the margins of the fissure seem to have been absorbed and not merely to have been separated by intracranial pressure. In all cases the dura mater was torn in the line of the fissure, a condition which is not to be wondered at when we consider the firm adhesion of that membrane to the bone in young children. In a majority of the cases the brain substance beneath the fissure was also lacerated, and in some even to the extent of opening up the descending cornu of the lateral sinus. In these cases there can be no doubt that the fluid in the tumour is derived from the subarachnoid space. The *treatment* of this condition is very unsatisfactory, and from the evidence before us it seems much better to leave the tumour to nature unless it threatens to give way, which does not seem a common accident. The tumour may then be aspirated, and if this fails to do any good, as it probably will, a small puncture may be made and a fine drainage tube inserted as a last resource.

Fracture of the Base of the Skull.—The most serious, and indeed a

very commonly fatal form of fracture of the skull, is that which extends through its *base*. It may occur in three ways. 1. It is usually caused by direct violence, as by a fall or a blow upon the vertex or side of the head, producing a fracture which extends from the point struck across to the base of the skull (p. 722). 2. It may possibly take place as the result of *contrecoup*, the blow being received on the forehead, back, or side of the head, and the jar of the bones expending its greatest violence on and fracturing the base of the skull; although as before stated (p. 722), there is but little evidence of this form of fracture; and 3, by the impact of the spine against the condyles of the occipital bone causing a fracture that radiates from the foramen magnum. This kind of fracture of the bone is well illustrated by the annexed cuts (Figs. 291, 292), taken from patients of mine who fell from a height on the head. The effects will vary according to the character of the

Fig. 291.—Splintering of edges of the Foramen Magnum and Radiating Fracture of Base of Skull from Fall on Vertex.

Fig. 292.—Fracture of Base by Fall on Vertex. Both Condyles broken off and driven in. Vertex was fissured.

surface on which the person falls. If hard, as on stone, the vertex will be smashed in, and if there be fracture of the base, it will be occasioned in the first way. If the head strikes soft ground, the body will be violently projected against the base of the skull, and the third variety of fracture may be occasioned by the force of the impact. One great danger in fracture of the base arises from the concomitant injury to the brain, either by direct laceration or by the extravasation of blood on its under surface. The important nervous centres that lie directly upon the parts of the skull that are broken are specially liable to injury, and free hæmorrhage often takes place from a torn sinus or a ruptured cerebral artery. Another danger of equal importance is septic meningitis, which is a cause of death in a considerable number of these cases. Its occurrence is explained by the fact that a very large proportion of all fractures of the base of the skull are compound. All cases which implicate the tympanum with rupture of the membrana tympani, all those which fracture the basilar process and tear the mucous membrane at the upper part of the

pharynx, and all those implicating the sphenoidal sinus and the cribriform plate of the ethmoid are compound fractures, and are exposed to all the accidents to which those injuries are liable. A good example of the way in which such injuries may prove fatal occurred in a case under my care in 1872. The patient was a woman, aged twenty-seven, who fell from a first-floor window into the street below. She received a violent blow on the face, fracturing the upper and lower jaws, the zygomatic arches, and the nasal bones. She soon recovered consciousness, and showed no signs of serious cerebral injury. However, on the second day symptoms of meningitis set in, and on the third day she died comatose. The *post-mortem* examination showed the usual signs of septic meningitis, and the source of the mischief was found to be a small puncture of the dura mater made by a triangular fragment of the thin bony roof of the sphenoidal sinus which had become displaced vertically, opening up the sinus below by tearing the mucous membrane. The fragment was isolated by the branches of a fissured fracture which extended backwards from the frontal bone, but at no other part was the dura mater injured. The brain showed superficial bruises in the frontal lobes.

Fractures of the Base, though very frequently fatal, are not invariably so. Not only does it occasionally happen that patients with all the signs of fracture of the base of the skull make a complete recovery, but in the different Museums specimens illustrative of repair after this accident may be met with. Thus, in the Museum of the Royal College of Surgeons, there is the skull of a person who lived two years after a fracture of this kind.

Signs.—Fracture of the base of the skull is very commonly suspected when

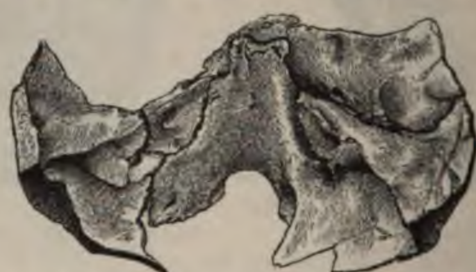

Fig. 293.—Fracture of Base of Skull proving fatal by injury to Medulla.

symptoms indicative of serious injury to the brain speedily follow a severe blow upon the head. Those parts of the nervous centres that are most important to life are more liable to injury in this than in other fractures of the skull; the same violence that occasions the fracture injuring the contiguous portions of brain, or lacerating some of the large venous sinuses at the base of the skull, and thus giving rise to abundant intracranial extravasation of blood. The patient whose skull is represented in Fig. 293 died from injury to the medulla oblongata and hæmorrhage into its substance; a result which can hardly be wondered at, when the splintered condition of the margin of the foramen magnum is taken in consideration. There was no other serious injury to the brain. After a short period of unconsciousness, the patient became noisy and talkative, and was somewhat troublesome on his way to the hospital, but almost immediately after admission, his respiration and pulse [illegible]n to fail, and he died in half an hour or less from the time of the accident.

The signs of fracture of the base of the skull will necessarily vary according to the seat of injury. When the fissure extends through the *anterior fossa*, there may be extravasation of blood into the orbit or beneath the conjunctiva, or free hæmorrhage from the nose. When it implicates the *middle fossa*, there is, very frequently, fracture of the petrous portion of the temporal bone, with rupture of the tympanic membrane, and then there will be bleeding or a watery discharge from the ears. When the *posterior fossa* is the seat of fracture, the signs are more equivocal. In some cases, however, discoloration of the skin from extravasated blood behind the mastoid process and at the back of the neck, when there has been no direct injury in that situation, may indicate the situation of the fissure.

There are two signs, the occurrence of which, separately or together, affords strong presumptive evidence of the existence of this kind of fracture: 1. The Escape of Blood from the interior of the Cranium through the ears, nose, or into the orbit; and 2. The Discharge of a Serous Fluid from the Ears, and occasionally from other parts in connection with the base of the skull.

1. The occurrence of **Bleeding from one or both Ears** after an injury of the head cannot by itself be considered a sign of much importance, as it may arise from any violence by which the membrana tympani is ruptured, or the cartilage of the pinna separated from the bone, without the skull necessarily being fractured. If, however, the hæmorrhage be considerable, trickling slowly out of the external auditory meatus in a continuous stream; if the blood with which the external ear is filled pulsate; and more especially if the bleeding last for three or four hours and be associated with other symptoms indicative of serious mischief within the head, and if it have been occasioned by a degree of violence sufficient to fracture the skull, we may look upon the hæmorrhage as strong evidence that a fracture of the base, extending into the petrous portion of the temporal bone, has taken place, and that, perhaps, one of the venous sinuses in its neighbourhood is torn (Fig. 294). The evidence, however, is only presumptive; it is not positive as to fracture of the base of the skull through its petrous portion, nor indeed of any intracranial injury whatever. Copious hæmorrhage from the ear to the extent of many ounces has been known to occur from a fracture of the anterior and inferior part of the meatus auditorius externus, in consequence of the condyle of the lower jaw being forcibly driven up against it, the jaw itself having been fractured.

Fig. 294.—Fracture of Temporal Bone passing through the Tympanum and tearing the Meningeal Artery (A).

Hæmorrhage into the Areolar Tissue of the Orbit and Eyelid, giving rise to extensive ecchymosis of the lid, possibly with protrusion of the eyeball itself, often accompanies fracture of the orbital plate of the frontal bone. The ecchymosis that occurs in these cases arises from the filtration of blood from the interior of the skull, through the fracture, into the loose areolar tissue adjacent to the injured bone. It differs remarkably in appearance from an ordinary "black eye." In the latter case, the extravasated blood lies in the subcutaneous tissue immediately beneath the skin, and sometimes the skin of the lids is also bruised, giving them a reddish-purple colour: but the blood does not find its way to the subconjunctival tissue, being shut off by the attachment of the palpebral ligament to the margin of the orbit. In the ecchymosis from fracture the extravasated blood advances from the orbit, and is shut off from the subcutaneous tissue of the lids by the palpebral ligament, while it readily finds its way beneath the conjunctiva. In the more severe cases the lids may be tense, greatly swollen, and of a bluish-purple colour, the subconjunctival tissue may be distended with blood, and the eyeball distinctly protruded. It is only when abundant that subconjunctival hæmorrhage is of any value in the diagnosis of fracture. A small extravasation may be the result of a direct blow on the eyeball, or a conjunctival vessel may have ruptured during the violent exertion which may have accompanied the accident. In well-marked cases the hæmorrhage may be venous or arterial. When venous, it probably arises from a fracture implicating the body of the sphenoid bone, and tearing the wall of the cavernous sinus. When arterial, it may, as Hewett has shown, be the forerunner of a circumscribed traumatic aneurism of the orbit.

Bleeding from the Nose or Mouth may of course arise from any injury of these parts without the skull being implicated; yet in some cases of fracture of the skull the hæmorrhage proceeds from the interior of the cranium, through a fissure in the roof of the nasal fossa; it then indicates a fracture through the ethmoid and sphenoid bones. In a patient of mine who died five weeks after an injury of the head, accompanied by bleeding from the nose, a fracture was found extending across one orbital plate of the frontal bone, and separating its articulation with the ethmoid. In this case, the nature of the injury was suspected from the fact of the nose itself having been uninjured by the blow, although the hæmorrhage from it was very considerable and continuous; for it is in the quantity and duration of this hæmorrhage that its value as a diagnostic sign consists.

Vomiting of Blood may occur in these cases, from the blood having found its way through the fractured ethmoid or sphenoid down the nose and through the posterior nares into the pharynx and stomach. The vomited blood is dark, grumous, and mixed with the contents of the stomach. In some rare cases, in which the petrous portion of the temporal bone is fractured, and the middle ear opened, but without injury to the tympanic membrane, no bleeding from the external ear ensues, but the blood escapes into the pharynx through the Eustachian tube. In some cases there may be a combination of these different signs. Thus, in a patient of mine at the hospital, there was hæmorrhage into the left orbit and from the left nostril, with copious vomiting of blood, and bleeding from the right ear, following a blow upon the forehead. The diagnosis, which was verified after death, was a fissure of the skull extending through the left orbital plate of the frontal

bone, the ethmoid, and probably the sphenoid on that side, and a fracture of the petrous portion of the right temporal bone.

2. The **Discharge of a thin Watery Fluid** from the interior of the skull sometimes occurs ; and, when it does, it is the most certain sign of fracture of the base that we possess. Although the occurrence of a discharge from the ear after certain injuries of the head had been observed by Van der Wiel, O'Halloran, and Dease, in the early part and middle of the last century, no attention was paid to the subject by later surgical writers ; and it appears to have been completely lost sight of until Laugier, in 1839, again directed the attention of Surgeons to this interesting phenomenon. Since this period, it has often been observed and attentively studied ; and the nature and sources of the discharge have been particularly investigated by Laugier, Chassaignac, Robert, Guthrie, and Prescott Hewett. The discharge usually takes place through the ear, but it may occur from the nose ; I have seen one instance of this, and Robert mentions another. Still more rarely it takes place from a wound in the scalp communicating with the fracture. Cases of this kind have been described by Hey, O'Callaghan, Robert, Hewett, and other Surgeons. One such instance was communicated to me by one of the pupils of University College, a few years ago. A boy received a wound on the back of the head, with a depressed and comminuted fracture of the skull. On the nineteenth day after the receipt of the injury, a large quantity of serous fluid began to escape through the wound, and continued to do so profusely until his death from coma four days later.

This watery discharge is an exceedingly valuable though most serious sign ; and Robert, who investigated the phenomenon with much closeness, stated that the cases in which it happens always terminate fatally. This, however, is an error ; for a number of cases have occurred at University College Hospital and elsewhere, in which adult patients recovered, although many ounces of fluid were discharged from the ear. It is usually associated with symptoms indicative of serious injury to the base of the brain ; but to this there are also exceptions, for I have seen it in cases of injury of the head unaccompanied by any severe cerebral symptoms. Generally it occurs in young people. Robert says that it does so invariably ; but Hewett states that in most of the instances in which he has seen it the patients were above thirty years of age. In one of my cases, the patient was fifty-eight years of age : and in six other instances in which I have observed it, the patients were all adults. In all cases of recovery that I have witnessed, some deafness of the ear from which the discharge occurred has been left, though this does not seem to be an invariable consequence of the injury.

The *Quantity* of fluid that is thus discharged is always very considerable, the pillow usually becoming soaked by it, which may be the first thing to attract attention to it. It is often necessary to keep a piece of sponge or a pledget of lint against the ear, in order to prevent the fluid from wetting the patient as it trickles out ; and, if a cup be so placed as to collect it, an ounce or two will speedily accumulate. Laugier states that he has seen a tumblerful discharged in a short time, and as much as twenty ounces has been known to be poured out in three days. The flow is usually continuous for several days, after which it ceases. At first the fluid that is discharged is usually tinged with blood, but this soon ceases, and it then flows clear. Its *physical and chemical characters* are those of a perfectly clear, and watery fluid, of

low specific gravity (1007–8), containing a considerable quantity of chloride of sodium, with a little albumose in solution, and traces of a substance, known as pyrocatechin, which, like sugar, reduces copper salts. The fluid is not coagulable by heat or nitric acid.

The **Source of this Discharge** has been the subject of much speculation, but the characters of the fluid, and the large quantity in which it sometimes escapes, prove it to be undoubtedly the cerebro-spinal fluid. Laugier's theory that the discharge consists of the serum of the blood filtered through a crack in the bone has nothing to support it. The large quantity of the fluid, and above all the fact that it occasionally escapes from the nose, demonstrate the fallacy of the view that it is furnished by the internal ear.

In order that the fluid be discharged, the membranes of the brain must have been torn opposite the outlet by which it is poured forth, in such a way as to open up the subarachnoid space. This has actually been ascertained to be the case, by carefully conducted dissections. When it is discharged through the ear, the laceration, as Bérard has remarked, must have extended through the prolongation of the arachnoid which surrounds the auditory nerve in the internal auditory canal. When it is poured out through the nose, the fracture has probably extended through the cribriform plate of the ethmoid bone, and laid open the arachnoid surrounding the filaments of the olfactory nerve.

The diagnostic value of watery discharge from the ear varies, according to Prescott Hewett, with its relation to the hæmorrhage which may occur. He divides cases of watery discharge from the ear after injuries of the head into three classes. In the first class, the discharge is watery from the first, and abundant, being preceded by little or no blood, and beginning immediately after the accident. This is undoubtedly cerebro-spinal fluid, which escapes through a fracture of the petrous bone implicating the internal auditory canal. In the second class, there is copious and prolonged bleeding from the ear, followed by the watery discharge. Here, too, there is fracture of the petrous bone; but its exact situation is uncertain. In these cases, the diagnosis will rest upon the prolonged hæmorrhage, rather than on the watery discharge. In the third class, there is but little bleeding after the injury, and the watery discharge, which is variable in quantity, varies also in the time of its appearance. In these cases the diagnosis must remain doubtful. Hewett mentions two cases which occurred at St. George's Hospital in which a copious watery discharge flowed from the ear. In neither of these was any fracture of the petrous portion of the temporal bone found after death. In one the membrana tympani was ruptured, and the cavity of the tympanum was "intensely vascular;" in the other, "the discharge was connected with a fracture of the lower jaw just below the condyle: the lower fragment had perforated the wall of the meatus auditorius."

The facial nerve may be so injured by a fracture of the petrous portion of the temporal bone as to become paralysed at the time of the accident. But more frequently paralysis of this nerve does not come on until a later period, about the second or third week after the injury, and disappears after lasting about a month. This transient facial paralysis, accompanying some fractures of the base of the skull, has been attributed by Marshall to the pressure of inflammatory exudation, which gradually becomes absorbed as the fracture unites, and thus the compression of the nerve is removed after a time.

Treatment.—In the treatment of fracture of the base of the skull it must

not be forgotten that whenever bleeding appears externally, the fracture is compound, and that decomposition of the discharges, with consequent septic meningitis, forms one of the greatest dangers of the case. Fortunately, however, in a large proportion of cases the dura mater is intact, and consequently the danger is greatly diminished. In fractures implicating the ethmoid and sphenoid bones, with hæmorrhage from the nose, little can be done to prevent decomposition; but the nasal fossæ may be washed out with some antiseptic solution to remove decomposing clots or discharge, and some iodoform should be blown into the cavity as high up as possible. In fractures affecting the tympanum, with rupture of the membrana tympani, the prevention of decomposition is more hopeful, although the Eustachian tube communicating with the upper part of the pharynx causes some degree of uncertainty. Yet, as it is lined with ciliated epithelium, it is quite possible that the causes of decomposition may not reach the fracture by that route. The ear should in such cases be carefully syringed out with a solution of carbolic acid in water (1 in 30), after which some iodoform may be blown on to it. It may then be plugged either with antiseptic gauze or wool, a large dressing of the same material being applied over the side of the head. The syringing must be gently done, and the carbolic solution should not be too strong, or it may cause some inflammation in the middle ear. The dressing must be changed as often as may be necessary. In other respects the treatment of fracture of the base of the skull must be conducted on those general principles that guide us in the management of simple fractures of the cranium, such as ice to the shaved head, a calomel purge, low diet, and absolute quietude in a darkened room. In many cases, the brain is so injured in its most vital parts that speedy death is the result. When recovery takes place, it is necessarily slow and liable to retardation from meningitis of an acute or subacute and chronic character.

DEPRESSED FRACTURE OF THE SKULL.—It occasionally though very rarely happens that, in consequence of a blow, a portion of the skull is depressed without being fractured, and even without any serious cerebral symptoms occurring. Such depression without fracture can, however, occur only in children, whose skulls are soft and yielding. In adults it cannot happen without the occurrence of partial or incomplete fracture. Many, if not all, of the so-called "congenital depressions" that are met with in the skull are the result either of violence inflicted on the cranium at birth, usually in instrumental labours, or of falls and blows upon the head in early infancy. Such depressions are smooth, concave, and sometimes symmetrical, and present very different characters from the irregular outline of an ordinary fracture. They never present the characters of a fissure; there is no such thing as a congenital fissure of the skull.

In the **Diagnosis** of depressed fracture, it is important to remember that the apparent depression produced by an extravasation under the scalp may simulate this injury very closely. (See p. 716).

Varieties.—Depressed fractures of the skull may either be simple, without wound of the scalp; compound; or comminuted. In the majority of cases, whether the fracture be simple or compound, there is comminution of the bone; the fragments being perhaps driven into the brain.

Sometimes, though very rarely, the **external table** alone is depressed and driven into the diploë. Over the frontal sinuses, it may be broken in, as I

have seen happen from the kick of a horse, without the inner table being splintered, or any bad consequence ensuing.

The **inner table** may be fractured without any apparent injury to the outer table; and it may not only be so fractured, but a portion of it may be depressed without the outer table being injured (Figs. 297, 298).

In all ordinary depressed fractures, both tables are depressed, but the internal table is splintered to a greater extent than the external one. This is especially the case when the fracture is the result of gunshot injury, or when it has been occasioned by blows with a pointed weapon, as the end of a pick, or a large nail, or the sharp angle of a brick. In these latter fractures, which constitute the dangerous variety termed **Punctured**, the outer table may be merely perforated or fissured, whilst the inner is splintered into numerous fragments, for the extent of a square inch or more. This splintering of the inner lamina of the skull to a greater extent than the outer has attracted much attention, being of considerable practical moment. It is often said to be owing to its being more brittle than the external table. This,

Fig. 295.—Fracture of the Skull from Gunshot Injury from within: Splintering of Outer Table.

Fig. 296.—The same, natural size.

however, I do not consider to be the only cause, for if the force be applied in the opposite direction, the outer table will be found to be more extensively splintered than the inner. It is seldom that we have an opportunity of examining such a case; but, some years ago, a man was brought to the Hospital who had discharged a pistol into his mouth and upwards through the brain. The bullet had perforated the palate and passed out at the upper part of the cranium, near the vertex. On examining the state of the bones, it was found that the outer table of the skull was splintered to a considerably greater extent than the inner one, showing clearly the influence of the *direction* of the fracturing force (Figs. 295, 296). This case led me to make further experiments on the dead body; and I found that the outer table is always more splintered when the blow is struck from the inside of the skull outwards. Teevan, as the result of numerous experiments by firing bullets and driving pointed bodies through the skull, came to the same conclusion that under all circumstances the aperture of exit is the larger. This effect is produced by three causes: 1st, the bullet or pointed instrument loses some of its momentum in passing through the first table with which it comes in contact, and thus does not make so clean a puncture in the second; 2ndly, if the instru-

blunt body, such as a bullet, it drives before it fragments of the it passes through, and thus the aperture of exit is made by the ball fragments, and the blow being more diffused splinters the second widely; lastly, the first table penetrated is well supported by the ile the second, supposing it to be the inner, has only the imperfect f the soft brain. That this last is an important cause we may see amiliar illustration of driving a nail through a board. If the board orted on its under side the nail will probably carry before it large rom that surface as it passes through the wood. But if the same upported on a block of wood and the nail driven through, then the f exit will be as small as that of entry. It occasionally happens as of sabre or hatchet cuts on the head that a longitudinal incised ccurs, in which the outer table is merely notched, whilst the inner ntered along the whole line of the blow. This is in point of fact an punctured fracture, and the wide area of splintering of the inner ie to the same cause as when a nail is driven in. In other cases,

xternal Table Slightly Depressed.

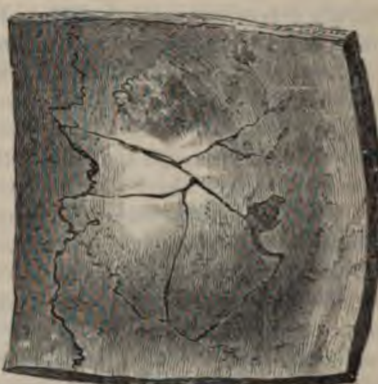

Fig. 208.—Internal Table Depressed and Fissured.

ortion of the skull is completely sliced off, hanging down in a flap lp, and exposing the brain or its membranes.

al and very important kind of punctured and depressed fracture is ich, by the thrust of a stick, umbrella, or other blunt-ended body rbit, the orbital plate of the frontal bone, or the cribriform lamella noid, is perforated, and the dura mater or brain wounded. In such is sometimes no obvious external wound, the stick having passed up upper eyelid; and it is conceivable that the same result might be even by a thrust up the nostril. Death results either from wound of nous sinus and intracranial extravasation of blood, or from septic ncephalitis following the wound of the dura mater and brain.

ry important to observe that *the inner table may be very extensively nd depressed, without any fracture of the outer table.* Of this e injury twenty cases are recorded as having happened in the civil war. One recovered, the diagnosis being made by finding ered inner table in a sequestrum which was removed. The rest ntracranial mischief, and the diagnosis was not made during life.

Most commonly when the inner table is thus fractured or depressed the outer table is fissured. The accompanying cuts (Figs. 297, 298), taken from photographs of a preparation in the Army Medical Museum, Washington, represent a case of extensive gunshot fracture with depression of the inner table of the left parietal bone without fracture of the external table. The patient was struck obliquely on the side of the head by a musket-ball, which inflicted a scalp-wound. There was no sign of cerebral disturbance until two days after the injury, when symptoms of compression set in. The skull was carefully examined through the wound for fracture; none could be found. The symptoms of coma increased and proved fatal on the tenth day, when the inner table of the left parietal bone was found extensively starred and depressed (Fig. 298), without any fracture of the outer table (Fig. 297). There was a wound of the dura mater and an abscess in the cerebral hemisphere —in fact, all the appearances and sequences of an ordinary "punctured fracture." This case demonstrates clearly the possibility of extensive fracture with depression of the inner table, whilst the outer remains unbroken.

The **Symptoms** of a depressed fracture of the skull are of two kinds: those that are dependent upon the injury to the bone, and those that result from the concomitant compression or laceration of the brain.

When the scalp is not wounded, the depression may sometimes be felt; but very commonly it is masked by extravasation of blood about it. In all cases of doubt, *when symptoms of compression of the brain exist* (p. 745), an incision should be made through the scalp at the seat of injury, and the state of the skull examined. When there is a wound in the scalp communicating with the fracture, the Surgeon detects at once the existence of depression and comminution by examining the bone with his finger through the wound. When the fragments that are depressed are impacted and firmly locked together, so as to form an unyielding mass, symptoms of compression of the brain, to a more or less marked degree, may result. But if the fracture be very extensive, and the fragments, though somewhat depressed, lie loose, and if they be yielding and do not exercise a continuous pressure on the brain, it occasionally happens that the symptoms of compression are entirely wanting, and no cerebral disturbance comes on for some days, even though the injury be very extensive. A man twenty-four years of age was admitted into University College Hospital, having been struck on the forehead by the sharp edge of a quoit. The frontal bone was extensively comminuted, twelve fragments being removed, and the dura mater being exposed to a considerable extent; yet no bad symptoms occurred until the ninth day, when inflammation of the brain and its membranes set in, and he speedily died.

In other cases again, more especially in children and young persons, in whom the bones are soft and yielding, fracture with depression may exist to a considerable extent, without any symptom of compression being produced,— the patient living with a portion of his skull permanently beaten in. I have several times seen persons in after-life with large flat depressions of the skull, the result of injuries sustained in childhood, who presented no signs of cerebral disturbance. It is rare, however, to meet with a recent case of depressed fracture in the adult without signs of compression of the brain. But, though rare, it is not impossible; and Green mentions a case of a man whose skull was depressed to the extent of the bowl of a dessert-spoon, without any symptoms of compression.

When the signs of compression are well marked, it must not be assumed that the pressure caused by the depressed fragments of bone is in all cases the sole or even the chief cause of the symptoms. It is scarcely possible for a man to suffer from a severe depressed fracture without serious bruising and laceration of the brain substance beneath and a more or less extensive intracranial extravasation of blood. Both these conditions are important factors in producing the symptoms. The celebrated case so often quoted, in which Cline trephined a man who had been unconscious for thirteen months after a fall on the head, which caused a slight depression in the skull, restoring him almost immediately to consciousness, will hardly bear investigation. The man had been pressed into the navy, and was consequently likely to feign disease to escape from it, and there are many cases of malingering on record quite as extraordinary as his. During the whole period of his "insensibility" he was able to make signs with his "lips and tongue" when he wanted food. This fact alone would be sufficient to throw the gravest doubts upon the genuineness of the case.

Wounds of the Dura Mater.—The great danger in cases of depressed and comminuted fracture arises not only from the compression of the brain, but from the rapidity with which inflammation (p. 771) so frequently follows the injury. This is due partly to the sharp fragments wounding and irritating the membranes of the brain, but chiefly to the septic matter which almost inevitably forms within the skull after these injuries, unless efficient means are taken to prevent it. In a compound depressed fracture the conditions present are as follows: Sharp fragments of the inner table are lying pressed against the dura mater, or possibly penetrating it and the arachnoid; the subarachnoid space is thus opened and the brain itself possibly wounded; the fragments are surrounded by more or less extravasated blood, and in a few hours a considerable amount of inflammatory exudation will necessarily be added. All this decomposable material is in communication with the air through the fissures in the bone, and at the same time these fissures allow of but imperfect drainage from within the cavity of the skull. Consequently, the decomposing discharges are pent up and burrow within the cranial cavity. If the dura mater were not wounded at the time of the accident, it will inevitably soon be perforated by ulceration at the point at which the sharp fragments of the inner table, bathed in putrid pus, are pressing against it. In either case, the subarachnoid space is opened and the septic matter diffuses itself widely, giving rise to the usual symptoms with the fatal termination characteristic of meningitis. If the fragments are removed early and the external wound is left open so as to provide perfect drainage from within the skull, the dangers of secondary perforation of the dura mater are very slight; and even should that membrane have been wounded at the time of the accident the patient has a fair chance of escaping diffuse meningitis; for adhesive inflammation may occur within a few hours, and thus present a barrier to the diffusion of any septic matter that may form afterwards. If, with the removal of sharp fragments and the provision of good drainage, we combine some perfect method of antiseptic treatment of the wound, the danger to the patient, though still great, will be most materially diminished. Indeed, a wound of the dura mater, however slight, is a dangerous complication. This is more especially the case in those injuries in which the inner table is extensively splintered, as in the different forms of punctured fracture. In these cases

Hæmorrhage into the Areolar Tissue of the Orbit and Eyelid, giving rise to extensive ecchymosis of the lid, possibly with protrusion of the eyeball itself, often accompanies fracture of the orbital plate of the frontal bone. The ecchymosis that occurs in these cases arises from the filtration of blood from the interior of the skull, through the fracture, into the loose areolar tissue adjacent to the injured bone. It differs remarkably in appearance from an ordinary "black eye." In the latter case, the extravasated blood lies in the subcutaneous tissue immediately beneath the skin, and sometimes the skin of the lids is also bruised, giving them a reddish-purple colour; but the blood does not find its way to the subconjunctival tissue, being shut off by the attachment of the palpebral ligament to the margin of the orbit. In the ecchymosis from fracture the extravasated blood advances from the orbit, and is shut off from the subcutaneous tissue of the lids by the palpebral ligament, while it readily finds its way beneath the conjunctiva. In the more severe cases the lids may be tense, greatly swollen, and of a bluish-purple colour, the subconjunctival tissue may be distended with blood, and the eyeball distinctly protruded. It is only when abundant that subconjunctival hæmorrhage is of any value in the diagnosis of fracture. A small extravasation may be the result of a direct blow on the eyeball, or a conjunctival vessel may have ruptured during the violent exertion which may have accompanied the accident. In well-marked cases the hæmorrhage may be venous or arterial. When venous, it probably arises from a fracture implicating the body of the sphenoid bone, and tearing the wall of the cavernous sinus. When arterial, it may, as Hewett has shown, be the forerunner of a circumscribed traumatic aneurism of the orbit.

Bleeding from the Nose or Mouth may of course arise from any injury of these parts without the skull being implicated; yet in some cases of fracture of the skull the hæmorrhage proceeds from the interior of the cranium, through a fissure in the roof of the nasal fossa; it then indicates a fracture through the ethmoid and sphenoid bones. In a patient of mine who died five weeks after an injury of the head, accompanied by bleeding from the nose, a fracture was found extending across one orbital plate of the frontal bone, and separating its articulation with the ethmoid. In this case, the nature of the injury was suspected from the fact of the nose itself having been uninjured by the blow, although the hæmorrhage from it was very considerable and continuous; for it is in the quantity and duration of this hæmorrhage that its value as a diagnostic sign consists.

Vomiting of Blood may occur in these cases, from the blood having found its way through the fractured ethmoid or sphenoid down the nose and through the posterior nares into the pharynx and stomach. The vomited blood is dark, grumous, and mixed with the contents of the stomach. In some rare cases, in which the petrous portion of the temporal bone is fractured, and the middle ear opened, but without injury to the tympanic membrane, no bleeding from the external ear ensues, but the blood escapes into the pharynx through the Eustachian tube. In some cases there may be a combination of these different signs. Thus, in a patient of mine at the hospital, there was hæmorrhage into the left orbit and from the left nostril, with copious vomiting of blood, and bleeding from the right ear, following a blow upon the forehead. The diagnosis, which was verified after death, was a fissure of the skull extending through the left orbital plate of the frontal

that this will relieve the symptoms, as the compression in almost all cases is not due solely to the depressed bone, but chiefly to extravasated blood within the cranium. (See Intracranial Hæmorrhage, p. 763.) Still the operation must to some extent relieve pressure, and may enable the Surgeon to remove the extravasated blood at the same time.

In a **Compound Depressed Fracture of the Skull**, as a general rule, the depressed bone should immediately be elevated.

If the fracture be accompanied by symptoms of compression the indications for operative interference are obvious. In these cases it is better always to expose the dura mater either by removing some fragments, as in all probability the compression is in great part due to intracranial hæmorrhage which may be between that membrane and the bone. If the dura mater should seem much distended with blood it may safely be incised with proper antiseptic precautions.

If the fracture be not accompanied by symptoms of compression it is still the duty of the Surgeon, as a general rule of practice, to elevate, and remove partly or completely, the depressed fragments. The patient who is suffering from a compound depressed fracture of the skull is exposed to the dangers of intracranial suppuration, and in order to lessen the risks of this serious complication a free exit for discharges must be provided. This can be done only by the removal of the depressed fragments which offer a serious obstacle to the escape of the discharges, and by their irritation favour the occurrence of meningitis.

The sooner elevation is done the better. Danger does not arise from early operation, but from delay. I have several times trephined primarily in such circumstances as these with success, and have never had occasion to regret doing so. Indeed, there is no class of cases in which the operation of trephining is attended with such successful results as those of depressed and comminuted fracture. Even though several days have elapsed and inflammation has set in, the proper treatment will be to remove the depressed and splintered bone, and thus give the patient his only chance—a slender one, it is true—of recovery. A man was admitted under Liston with a long depressed fracture on the side of the head, produced by a blow from a brickbat; though no sign of compression existed, yet symptoms of cerebral inflammation were speedily set up, and Liston trephined him on the fourth day after the accident; the man, who was perfectly conscious, walking into the operating theatre. A considerable splintering of the inner table was found, the fragments of which were removed. The dura mater having been punctured by one of the spicula of bone, diffuse suppuration of the membranes of the brain set in, and the patient died in a few days. In this case, however, the necessity for early trephining was clearly indicated, notwithstanding the absence of any symptom of compression.

Some cases of compound depressed fracture have recovered without operative interference. I had once under my care a case which illustrated this. The patient, a middle-aged man, fell on his head into an area, and had the greater part of the scalp stripped off from the anterior part of the head and the vertex; on the upper part of the left parietal bone was a starred and depressed fracture as large as a florin. As the depression was smooth, not more than a quarter of an inch in depth, and there was no symptom of compression, I drew the scalp forwards and left the bone untouched, the patient making an

low specific gravity (1007–8), containing a considerable quantity of chloride of sodium, with a little albumose in solution, and traces of a substance, known as pyrocatechin, which, like sugar, reduces copper salts. The fluid is not coagulable by heat or nitric acid.

The **Source of this Discharge** has been the subject of much speculation, but the characters of the fluid, and the large quantity in which it sometimes escapes, prove it to be undoubtedly the cerebro-spinal fluid. Laugier's theory that the discharge consists of the serum of the blood filtered through a crack in the bone has nothing to support it. The large quantity of the fluid, and above all the fact that it occasionally escapes from the nose, demonstrate the fallacy of the view that it is furnished by the internal ear.

In order that the fluid be discharged, the membranes of the brain must have been torn opposite the outlet by which it is poured forth, in such a way as to open up the subarachnoid space. This has actually been ascertained to be the case, by carefully conducted dissections. When it is discharged through the ear, the laceration, as Bérard has remarked, must have extended through the prolongation of the arachnoid which surrounds the auditory nerve in the internal auditory canal. When it is poured out through the nose, the fracture has probably extended through the cribriform plate of the ethmoid bone, and laid open the arachnoid surrounding the filaments of the olfactory nerve.

The diagnostic value of watery discharge from the ear varies, according to Prescott Hewett, with its relation to the hæmorrhage which may occur. He divides cases of watery discharge from the ear after injuries of the head into three classes. In the first class, the discharge is watery from the first, and abundant, being preceded by little or no blood, and beginning immediately after the accident. This is undoubtedly cerebro-spinal fluid, which escapes through a fracture of the petrous bone implicating the internal auditory canal. In the second class, there is copious and prolonged bleeding from the ear, followed by the watery discharge. Here, too, there is fracture of the petrous bone; but its exact situation is uncertain. In these cases, the diagnosis will rest upon the prolonged hæmorrhage, rather than on the watery discharge. In the third class, there is but little bleeding after the injury, and the watery discharge, which is variable in quantity, varies also in the time of its appearance. In these cases the diagnosis must remain doubtful. Hewett mentions two cases which occurred at St. George's Hospital in which a copious watery discharge flowed from the ear. In neither of these was any fracture of the petrous portion of the temporal bone found after death. In one the membrana tympani was ruptured, and the cavity of the tympanum was "intensely vascular;" in the other, "the discharge was connected with a fracture of the lower jaw just below the condyle: the lower fragment had perforated the wall of the meatus auditorius."

The facial nerve may be so injured by a fracture of the petrous portion of the temporal bone as to become paralysed at the time of the accident. But more frequently paralysis of this nerve does not come on until a later period, about the second or third week after the injury, and disappears after lasting about a month. This transient facial paralysis, accompanying some fractures of the base of the skull, has been attributed by Marshall to the pressure of inflammatory exudation, which gradually becomes absorbed as the fracture unites, and thus the compression of the nerve is removed after a time.

Treatment.—In the treatment of fracture of the base of the skull it must

t be forgotten that whenever bleeding appears externally, the fracture is mpound, and that decomposition of the discharges, with consequent septic eningitis, forms one of the greatest dangers of the case. Fortunately, however, in a large proportion of cases the dura mater is intact, and consequently e danger is greatly diminished. In fractures implicating the ethmoid and henoid bones, with hæmorrhage from the nose, little can be done to prevent composition; but the nasal fossæ may be washed out with some antiseptic lution to remove decomposing clots or discharge, and some iodoform should blown into the cavity as high up as possible. In fractures affecting the mpanum, with rupture of the membrana tympani, the prevention of decomposition is more hopeful, although the Eustachian tube communicating with e upper part of the pharynx causes some degree of uncertainty. Yet, as it lined with ciliated epithelium, it is quite possible that the causes of decomposition may not reach the fracture by that route. The ear should in such ses be carefully syringed out with a solution of carbolic acid in water in 30), after which some iodoform may be blown on to it. It may then be ugged either with antiseptic gauze or wool, a large dressing of the same aterial being applied over the side of the head. The syringing must be ntly done, and the carbolic solution should not be too strong, or it may use some inflammation in the middle ear. The dressing must be changed often as may be necessary. In other respects the treatment of fracture of e base of the skull must be conducted on those general principles that guide in the management of simple fractures of the cranium, such as ice to the aved head, a calomel purge, low diet, and absolute quietude in a darkened om. In many cases, the brain is so injured in its most vital parts that eedy death is the result. When recovery takes place, it is necessarily slow d liable to retardation from meningitis of an acute or subacute and chronic aracter.

DEPRESSED FRACTURE OF THE SKULL.—It occasionally though very rarely ppens that, in consequence of a blow, a portion of the skull is depressed ithout being fractured, and even without any serious cerebral symptoms ccurring. Such depression without fracture can, however, occur only in ildren, whose skulls are soft and yielding. In adults it cannot happen ithout the occurrence of partial or incomplete fracture. Many, if not all, f the so-called "congenital depressions" that are met with in the skull are e result either of violence inflicted on the cranium at birth, usually in strumental labours, or of falls and blows upon the head in early infancy. uch depressions are smooth, concave, and sometimes symmetrical, and present ery different characters from the irregular outline of an ordinary fracture. hey never present the characters of a fissure; there is no such thing as a ongenital fissure of the skull.

In the **Diagnosis** of depressed fracture, it is important to remember that e apparent depression produced by an extravasation under the scalp may mulate this injury very closely. (See p. 716).

Varieties.—Depressed fractures of the skull may either be simple, without ound of the scalp; compound; or comminuted. In the majority of cases, hether the fracture be simple or compound, there is comminution of the one; the fragments being perhaps driven into the brain.

Sometimes, though very rarely, the **external table** alone is depressed and iven into the diploë. Over the frontal sinuses, it may be broken in, as I

signs of inflammation of the brain, three from the effects of cold weather, and one only from diffuse meningo-encephalitis. In many of these animals large portions of cerebral substance were cut away without causing any inflammatory disturbance beyond the area actually injured. The experiments also showed conclusively that a five per cent. solution of carbolic acid may be applied with impunity to the brain or its membranes.

The statistics given by Kramer in an inaugural dissertation at Breslau in 1880 show no less conclusively the great advantages to be derived from antiseptic treatment. Of twenty-five cases of compound fracture of the skull with wound of the brain, in which no operation was performed, ten died, five from meningitis, and one from pneumonia, and the rest directly from the injury to the brain. Of twenty-five cases of primary trephining for injury, only two died, one from circumscribed meningitis and one from diffuse meningo-encephalitis; in twenty-one the wound healed by first intention. Of six cases in which secondary trephining was performed only one died with hernia cerebri. These results are certainly much better than any that had been obtained previous to the introduction of the antiseptic treatment.

The treatment should be carried out as follows: The wound must as soon as possible be covered with a piece of linen rag soaked in a three per cent. solution of carbolic acid in water. The whole head is then to be shaved and carefully cleaned with soap and water. If necessary it may be sponged with a weak solution of ammonia to get rid of grease; but, of course, in doing this the liquids used in washing must not be allowed to flow into the wound. The head is then cleaned with the carbolic solution (1 in 20), and this may be allowed to enter freely into the wound. It must not on any account be forcibly injected, as by so doing it might become widely diffused in the subarachnoid space or the brain might be injured. When the operation is completed the edges of the wound must be brought together, pared, if much contused, and very dirty, provision being made for drainage, and some efficient antiseptic dressing may be applied. It is not always possible to render the wound thoroughly aseptic, as much dirt may have been ground into it, and some time may have elapsed before the case is seen; but the dangers of septic meningitis are so great that it is always worth while to make the attempt even in apparently hopeless cases. In doubtful cases the wound should be freely powdered with iodoform. If no special antiseptic dressing is at hand the wound, after having been thoroughly washed with carbolic acid lotion, may be dressed with carbolic oil (1 in 10), or terebene and oil, and during the time it is necessarily exposed in dressing it may be irrigated with the antiseptic solution. Failing all other antiseptic dressings, the wound may be washed out with spirit and water and dressed with dry lint or cotton-wool, in the hope that decomposition of the discharges may be prevented by drying. The one thing that is more certain than anything else to ensure decomposition is washing the wound with common water and applying simple wet lint to it, as was formerly the universal practice.

All the precautions applicable to cases of injury of the brain, such as low diet, purging, perfect quiet, dry cold to the head, &c., must be employed as rigorously when the antiseptic treatment is adopted as when it is not.

It has been recommended in cases of simple depressed fracture, without injury of the brain or its membranes, to make an attempt to draw the [illegible]essed portion of bone to its normal level by means of a cupping-glass,

adapted to the uneven surface of the skull by means of a cell of glazier's putty.

Treatment of Punctured Fracture.—In all cases, as before stated, in which there is but slight injury of the external table, with considerable splintering and depression of the inner one, or when there is a narrow and deep depression of the bone, the trephine must be applied on different principles from those that guide us in its use in ordinary depressed fractures. In the punctured fracture it is applied, not to remove symptoms of compression which, in all probability, do not exist; but with the view of preventing the inflammation which will to a certainty be set up if the splinters of the inner table and pent-up decomposing discharges be allowed to continue irritating the membranes and brain. Hence it is a rule in surgery, in all cases of punctured fracture, to apply the trephine at once. In these cases a trephine with a large crown should be used, and the circle of injured bone itself must be sawn away (Fig. 303). Should, however, the use of the trephine have been delayed in these cases until inflammation has been set up, the instrument may still be applied with advantage. Many years ago a boy was admitted into University College Hospital, on the sixteenth day after having been struck on the side of the head by a large nail, which projected from a door that fell upon him. No symptoms of any kind had occurred until the eleventh day after the accident, when he became dull and lost his appetite; on the sixteenth day, that of his admission, he had suddenly become drowsy and delirious, but answered rationally when spoken to, and complained of pain in the head. The pupils were dilated, the skin hot, and the pulse quick. On examination, a small round aperture, from which some fetid pus exuded, was discovered on the right parietal eminence. On introducing a probe, which the hole just admitted, some rough bone could be felt. S. Cooper immediately trephined the boy, removing a circle of bone including the small aperture. The inner table corresponding to this was found splintered to some extent, and the dura mater was thickened and inflamed; but the patient recovered without a bad symptom.

Fig. 303.—Trephined circle round Punctured Fracture. Natural size.

Linear Cuts, as by sabre or hatchet, into the skull, penetrating the outer table, are apt to splinter the inner one, in the same way as occurs in a "punctured" fracture, to which they bear a close analogy. They require the same preventive trephining that is needed in the true punctured fracture, having for its object the removal of splinters and spicula, which would probably produce fatal meningitis if left.

The **Ultimate Results of Fracture of the Skull** in those who recover will more or less closely resemble the conditions described at p. 721, as the consequences of contusion of the cranium without fracture. Epilepsy was very frequent in the American war cases; partial or complete loss of vision was also one of the common sequences of such injuries. When deafness occurred, it was generally connected with impairment of other special senses, and often of the mental faculties.

When a depressed fracture of the skull is **complicated with a Fracture or other Injury of the Spinal Column,** it is sometimes difficult to know which symptoms are due to the one accident, and which to the other. In

such a case as this, however, we should, I think, treat the depressed fracture irrespectively of the spinal injury, thus giving the patient a chance of recovery, of prolongation of life, or, at least, of return of consciousness before death. A man was admitted under my care into the Hospital, with depressed fracture of the left parietal bone, and injury of the cervical spine, the precise nature of which could not be accurately determined. He was in a state of complete coma and paralysis. I trephined the skull and elevated the depressed portion of bone; he recovered his consciousness to a great degree, but died in a few days, apparently from injury to the spine. On examination after death, we found a fracture of the fifth cervical vertebra.

CEREBRAL COMPLICATIONS OF INJURIES OF THE HEAD.

These may be primary or secondary. The brain is subject to three principal **Primary States of Functional Disturbance** arising from injury; viz., 1. Concussion, 2. Compression, and 3. Cerebral Irritation. Any one of these may be followed by, or be complicated with, subsequent inflammation, which derives peculiar characteristics from the conditions with which it is associated, and from the injury by which it is occasioned.

In describing these different conditions, we are compelled to define the symptoms that characterize them more distinctly than is the case in actual practice, where they are not so clearly individualized, and become merged together to a considerable extent.

1. CONCUSSION OF THE BRAIN.—Concussion, or stunning, appears to be a shock communicated to the head from the application of such external violence as will produce commotion of the substance of the brain, or interfere with the circulation through it; in consequence of which its functions become suspended, usually in a slight and transitory degree, but occasionally to such an extent that the patient does not rally for many hours from the depressed state into which he is thrown.

The **Pathology** of concussion of the brain is very obscure; so much so, in fact, that the term must be considered to have rather a clinical than a pathological significance. Clinically the term is used to cover all those cases in which insensibility of a temporary character not due to any evident coarse lesion or compression of the brain follows an injury to the head. When cases of this kind, that have been clinically classed as concussion, have died without rallying, examination has always shown some actual lesion of the brain. In some cases the brain is ecchymosed in a punctiform manner, whilst in the most severe cases, portions of the brain substance, varying in size from minute points to patches an inch or more in diameter, have been disintegrated and more or less ecchymosed. In fact, no sharp line can be drawn either clinically or pathologically between the more severe cases of concussion and those of obvious cerebral laceration and contusion.

The theory that the symptoms of concussion can be produced simply as the result of a temporary arrest of the normal cerebral action by a violent vibration of the nerve tissue is not now generally accepted. There is, however, much reason for believing that a condition of cerebral anæmia is the essential cause of the symptoms. This anæmia partly no doubt depends upon the general vaso-motor paralysis and weak action of the heart, which allow the blood to stagnate in the relaxed vessels, especially in the veins of the abdominal viscera and

muscles. A blow on the top of the head may, however, produce as its chief effect small hæmorrhages about the base of the brain, especially in the medulla. The experiments of Duret, and more recently those of Miles, of Edinburgh, indicate that this damage to the base of the brain is produced by waves of cerebro-spinal fluid impinging upon it, and the latter observer suggests that the condition of cerebral anæmia is caused by reflex stimulation of the bulb. We have already seen that, in fatal cases, minute hæmorrhages into the brain substance are frequently found, and it has been suggested that multiple capillary hæmorrhages may be the cause of the symptoms in cases ending in recovery. It seems, however, more likely that such hæmorrhages are the result of sudden disturbances in the cerebro-spinal fluid, rather than that they are themselves the cause of the symptoms.

The **Signs** of concussion vary according to the severity of the injury to the brain. In the slighter cases, the patient may merely feel giddy and confused for a few minutes. In others, consciousness is not affected, but the patient feels faint and weak, and is unable to stand. In the more severe form—in that degree, indeed, which usually accompanies any severe injury of the head—the surface of the body becomes cold and pale; the temperature falls to 97° F., or even to 96° F., if the accident has occurred in cold weather; the sufferer is motionless and insensible, or answers only when spoken to in a loud voice, relapsing again into speedy insensibility, or rather semi-consciousness; the pulse is feeble; the respiration is slow and shallow; the pupils are usually contracted, but may be dilated, and generally respond to the action of light, and the sphincters are usually relaxed; the limbs are flaccid, and muscular power is impaired or lost. After this condition, which is the first stage of concussion, has lasted for a few minutes or hours, according to the severity of the shock, the second stage comes on; the circulation gradually re-establishing itself, the pulse becoming fuller, and the surface warmer. As reaction becomes fully established, the temperature rises slightly above the normal standard, the degree of elevation being in proportion to the severity of the concussion. In slight cases the thermometer will rise to 99° F. or 99·5° F., while after more severe injuries it may reach 100° F., beyond which point it seldom passes in cases of simple concussion. About this time the patient very commonly vomits; probably as a consequence of cerebral hyperæmia following the anæmia which exists during profound concussion. After vomiting, the sufferer quickly rallies. In the more severe cases, the symptoms that have just been described are so strongly marked that the patient appears to be moribund—prostration of all nervous and physical power being complete, the surface being cold and clammy, as in death, the eyes glassy, the pupils either contracted or widely dilated, the pulse scarcely perceptible and intermittent. In this state the patient may lie for hours, recovery being slow and the concussion merging into some other and perhaps more serious affection of the nervous centres; or, indeed, in some cases, speedily terminating in death, apparently by failure of the heart's action or arrest of respiration. But it may truly be said that every case of concussion in which unconsciousness, though but momentary, has been produced, is a most serious one.

The **Terminations** of concussion are various. We have already seen that in most cases this affection speedily gives way to complete recovery; although slight headache, some degree of giddiness, confusion of thought, and inaptitude for mental occupation, may last for a few days before the mental powers are

completely re-established. In these it is probable that no coarse lesion of the brain substance has taken place. In other cases, the concussion may rapidly terminate in death, and in these it will always be found that distinct contusion or laceration of the brain substance has occurred. Between these conditions there are several intermediate states. Thus, recovery may be complete, but a permanently irritable state of brain may be left; the patient, though capable of the ordinary duties of life, becoming readily excited by slight excesses in diet or in the use of stimulants, or by mental emotion, though not of an inordinate intensity. Individuals thus affected, suffering from a preternaturally irritable brain, sometimes die suddenly in the course of a few months, or a year or two, after the receipt of the injury.

In other cases the patient's recovery is incomplete. He remains for a long time unable properly to follow his usual occupation or to mix in the ordinary business of life. In such cases there is frequently a certain degree of impairment of mental power; the memory failing either generally or in certain important points, as with reference to dates, persons, places, or language. The speech is perhaps indistinct and stuttering. Impairment of vision is a very common consequence of these injuries. Asthenopia, with perhaps squinting or paralysis of the eyelid, may be left. The hearing may be impaired, or noises of various kinds set up in the ears. Epileptiform convulsions occasionally occur; sometimes, as the patient is recovering consciousness, he may be seized with a severe fit; but more commonly the convulsions do not come on as a primary consequence, but rather as a remote secondary result of the brain injury. There may be diminution or loss of muscular and of virile power, especially, as Hennen observes, when the injury has been inflicted upon the back of the head; and Holberton has noticed that, when the medulla oblongata has been injured, the pulse may continue preternaturally slow—an observation which I have had several opportunities of confirming. The symptoms here enumerated are spoken of collectively as "general nervous shock," or "traumatic neurasthenia," and are evidence of a more or less marked condition of nervous depression resulting from the injury. The condition will be further considered in connection with injuries of the spine, which are often followed by similar symptoms. In some of these cases the symptoms of concussion are but slight; perhaps even none are apparent, and the sufferer congratulates himself on his escape; but gradually impairment of nervous power, manifesting itself in one or other of the ways just mentioned, comes on, and the health continues broken through life.

In other cases, again, the symptoms of concussion may gradually terminate in those of compression; and not unfrequently reaction is followed by some inflammatory mischief when the concussion has been accompanied by laceration or contusion of the brain. Hippocrates truly observed that no injury of the head is too trivial to be despised, or too serious to be despaired of.

2. Compression of the Brain.—This is a common condition in injuries of the head, arising from a great variety of causes:—from the pressure of a portion of bone, of extravasated blood, of inflammatory exudation, or of pus formed within the skull, or from a foreign body lodged there.

In considering the **Pathology** of compression of the brain, it is of the greatest importance to distinguish clearly between the local effects of a compressing body on the part of the brain upon which it lies, and the effects of a general rise of intracranial pressure. We are here concerned only with the

latter condition. The brain is surrounded by the incompressible cerebro-spinal fluid, and hence it follows that the slightest diminution of the capacity of the cranium, as by the introduction of a foreign body, must raise the intracranial pressure, unless the fluid has a ready means of escape. Such an escape does undoubtedly occur, chiefly into the theca vertebralis, and the experiments of Dean show that the slightest pressure on the dura mater of a trephined animal does actually cause a corresponding rise in the pressure of the subarachnoid space. We must therefore conclude that an increase of intracranial pressure produces symptoms only when it reaches a degree sufficient to interfere with the circulation through the brain.

In whatever way occasioned, the **Symptoms**, although presenting some differences, are tolerably constant. The patient lies in a state of coma, stupor or lethargy, being paralysed more or less completely, heavy and drowsy, or insensible, not answering when spoken to, or only when addressed in a loud voice, and perhaps shaken at the same time. The breathing is carried on slowly and deeply, with a stertorous or snoring noise, and usually a peculiar blowing of the lips. The stertor appears to be owing to paralysis of the soft palate, which is thrown into vibrations during expiration by the passage of the air; the distension of the cheeks and blowing of the lips are due to the paralysis of these parts. One or both pupils are dilated and insensible to light; the pulse is full, often slow—in fact, a full, slow, laboured pulse is one of the most marked features in these cases; the fæces pass involuntarily from paralysis of the sphincter ani, and the urine is retained from paralysis of the bladder; the skin may be cool, but in many cases, on the contrary, is rather hot and perhaps perspiring; the temperature may rise to 106° F. If the pressure be unilateral, Horsley has observed that the temperature of the extremities is often higher on the side opposite that on which the pressure exists, probably as a consequence of vaso-motor paralysis. In some cases, on the other hand, there appears to be depression of temperature on the side of the body opposite to the lesion. Not unfrequently during this condition of stupor violent fits of convulsions may occur. This state of coma may become complicated by symptoms of inflammation; and, unless the cause that produces the compression be removed, it usually terminates speedily in death, the patient gradually sinking into more complete unconsciousness, and dying in an apoplectic condition. In other, but much rarer cases, the insensibility may continue almost an indefinite time, for many weeks or even months, until the compressing cause is removed, when the patient may recover consciousness, and the symptoms disappear.

The **Diagnosis** between *concussion* and *compression* has been sufficiently indicated in the preceding description not to require special mention here. But it must be remembered that, in many cases, one state merges into the other, so that the symptoms are not so distinctly marked as has been indicated; and they are more especially obscured when associated with inflammation.

With regard to compression it may be broadly stated that whenever the symptoms follow an injury to the head within twenty-four hours they are due to the pressure of fragments of bone in depressed fractures, foreign bodies in penetrating fractures, or extravasated blood in simple injuries. Compression from inflammatory exudation does not occur till the third day at the earliest.

3. Cerebral Irritation.—The third form of primary cerebral disturbance

which is met with in injuries of the head, differs very remarkably from both the preceding. The patient presents symptoms neither of concussion nor compression, nor is there any combination of the phenomena characterizing these two states; but the symptoms are altogether peculiar. For convenience of description, they may be divided into two groups, the *bodily* and the *mental*.

The **Bodily Symptoms** are as follows. The attitude of the patient is peculiar and most characteristic:—he lies on one side and is curled up in a state of general flexion. The body is bent forwards, the knees are drawn up on the abdomen, the legs bent, the arms flexed, and the hands drawn in. He does not lie motionless, but is restless, and often, when irritated, tosses himself about. But, however restless he may be, he never stretches himself out nor assumes the supine position, but invariably reverts to the attitude of flexion. The eyelids are firmly closed, and he resists violently every effort made to open them; if this be effected, the pupils will be found to be contracted. The surface is pale and cool, or even cold. There is no heat of head. The pulse is small, feeble, and slow, seldom above 70. The sphincters are not usually affected, and the patient will pass urine, when the bladder requires to be emptied; there may, however, though rarely, be retention.

The **Mental State** is equally peculiar. Irritability of mind is the prevailing characteristic. The patient is unconscious, takes no heed of what passes, unless called to in a loud tone of voice, when he shows signs of irritability of temper or frowns, turns away hastily, mutters indistinctly, and grinds his teeth. It appears as if the temper, as much as or more than the intellect, were affected in this condition. He sleeps without stertor.

The course taken by these symptoms is as follows. After a period varying from one week to three, the pulse improves in tone, the temperature of the body increases, the tendency to flexion subsides, and the patient lies stretched out. The mental state also changes. Irritability gives way to fatuity; there is less manifestation of temper, but more weakness of mind. Recovery is slow, but, though delayed, may at length be perfect; although in these, as in all other cases of cerebral disturbance, ulterior consequences may be manifested.

This form of cerebral disturbance may, from the peculiar irritability that characterizes it, be with propriety termed *cerebral irritation*.

The symptoms that have just been described usually follow blows upon the temple, or forehead, or occiput, and are probably due to superficial lacerations of the frontal lobes of the brain.

TREATMENT.—The treatment of these various conditions is often difficult owing to the fact that they seldom occur in practice with that amount of distinctness and particularity by which alone their characters can be conveyed in description, but are associated together in such a way that the exact state of the patient cannot so readily be made out. It would be useless to attempt to describe the shades and modifications of treatment required in the management of the different groupings of these various forms of traumatic cerebral disturbance. We must, therefore, content ourselves with describing the treatment of each state broadly and separately, and leave the consideration of the varieties that commonly present themselves in practice to the discretion of the Surgeon.

In the **Treatment of Concussion**, the first great indication is to re-establish the depressed energies of the circulation and of the nervous system. In effecting this, we must be careful not to overstimulate the patient. The safest practice is that which is applicable to the treatment of shock generally —to wrap the patient up warmly in blankets, to put hot bottles around him, or to employ frictions to the surface, and when he is sufficiently recovered, to allow him to swallow a small quantity of warm tea. Alcoholic stimulants of all kinds should be avoided, unless the depression be so great that reaction cannot be brought about without their agency; but an enema containing some ether or aromatic spirits of ammonia may be administered.

When reaction has come on, steps should be taken to prevent the occurrence of inflammatory mischief. If the concussion has been slight, it may be quite sufficient to purge the patient well, and to keep him quiet on a regulated diet for a few days, directing him carefully to avoid all alcoholic stimulants and mental exertion for some time. If the concussion has been more severe, and if the symptoms of reaction have been accompanied by indications of continuous cerebral disturbance, or have been followed by giddiness, headache, or confusion of thought, the safer plan will be to adopt immediate steps for the prevention of further mischief. Venesection used formerly to be extensively practised as a precautionary measure, in order to prevent undue reaction and inflammatory mischief following on head injuries. Perhaps our predecessors erred in the too frequent and liberal use of the lancet in these cases; I believe that Surgeons of the present day are too sparing in its use. In the young and robust the best possible effects follow venesection in head injuries, to the extent of from 12 to 16 ounces. In children, leeches advantageously take the place of the lancet. The patient should be freely purged, kept on a low diet, and, above all, should remain quiet in bed for some days.

Should impairment of the mental faculties or senses be left, the more prudent plan will be to have recourse to a mild antiphlogistic treatment, consisting of leeching, cupping, blistering, purging, and more especially a mild mercurial course, with strict avoidance of all mental and bodily stimulation. The patient must be carefully watched, and kept under proper supervision for some length of time, as serious symptoms are apt suddenly to declare themselves.

In all cases of **Coma from Compression** the pressure must be relieved before it can be expected that the coma will subside. But, besides this great and obvious indication, which must be carried out in different ways according to the nature of the compressing cause, there are certain general considerations to be attended to, by which the patient's condition may be much relieved. Thus the bowels should be freely opened by placing a drop of croton oil, mixed with a little mucilage, in the patient's mouth, or by the use of oleaginous or terebinthinate enemata. The urine is to be drawn off twice in the twenty-four hours, the room darkened and kept quiet, and ice or an evaporating lotion applied to the head. If the breathing becomes extremely laboured and the pulse very slow and full, free venesection is often of use, but no treatment can be of any real service unless the cause of the compression be removed.

The treatment of **Cerebral Irritation** will require to be varied in different stages of the condition. In the early stage, the treatment that I have found most successful consists in the avoidance of all active measures. Much harm

may result from bleeding, purging, and mercurializing the patient. Complete rest, the removal of all mental and sensory excitement, shaving the head, the application of ice, a mild aperient or an occasional enema, are all that can be done in the way of medical treatment. As the constitutional powers are depressed, they must not be too much lowered by complete abstinence from food; small quantities of milk and beef-tea must be given at intervals, but stimulants are rarely, if ever, required. Bromide of potassium is often very useful in 30-grain doses. In some cases where there is great restlessness, and some delirium, without any sign of encephalitis having supervened, chloral will be found of great value, or an opiate even may be given to quiet the patient and induce sleep. This cerebral irritation is the only form of primary cerebral disturbance in which I have seen opiates act beneficially; but their administration requires great care, and must not be ventured on if there be any elevation of temperature or quickness of pulse. Should the signs of depression give way to those of subacute meningitis, the patient becoming noisy, restless and sleepless, venesection may be practised with great advantage. The bleeding should be followed up by the administration of bromide of potassium or chloral. In the treatment of all these conditions, it is impossible to insist too strongly on the paramount importance of absolute rest and quiet. No conversation, lights, or noise should be allowed in the patient's room, and no injudicious attempts should be made to rouse him or to ascertain by inquiry if he is conscious. Much depends on careful and quiet nursing; on attention to minor details, as the avoidance of noises, of flickering lights; and on the frequent administration of liquid food in small quantities, or *per rectum.*

Summary of Treatment.—The following treatment should be applied in all cases of head injury attended with unconsciousness, whether special operative interference be needed or not:—

1. The head must be shaved and slightly elevated on hard pillows.
2. Any scalp wound must be treated antiseptically.
3. Hot bottles applied to the feet—an ice-bag to the head if there be signs of compression, but not in simple concussion or if the patient be collapsed.
4. From two to five grains of calomel placed on the tongue on the second day.
5. The lower bowel emptied by a turpentine enema on the second or third day, and the catheter used if necessary.
6. The room darkened—the necessary fire and lights being screened.
7. No conversation in the room allowed; all noises avoided; slippers substituted for creaking boots; the coal put on with the hand; the fire stirred with a stick.
8. The diet to consist of spoon-food—iced milk or at most chicken-broth, thickened with arrowroot or cornflour. Stimulants avoided if possible.
9. If the patient cannot swallow, nutritive enemata may be given every fourth hour.

CONTUSION AND LACERATION OF THE BRAIN.

Contusion and Laceration of the Brain and of its Membranes are frequent in injuries of the head, and are among the most important con-

lications of these accidents. The extent of injury inflicted upon the cerebral ıbstance has wide limits, from slight laceration without exposure, to enudation of the brain, disintegration, and escape of large portions of its ıbstance.

Causes.—Injury to the brain may be occasioned in various ways. The mplest form is, perhaps, that which is frequently met with in undepressed acture of the skull and sometimes happens without fracture, from simple oncussion or commotion.

Under these circumstances the laceration of the cerebral substance occurs ı most cases on the side of the head opposite to that on which the violence is pplied, usually at a point exactly opposite to that struck; much less frequently is found immediately beneath the part of the skull which received the blow. aceration of the brain is the commonest cause of death in simple fracture of he skull, the fracture itself when not compound being no more dangerous han a similar injury of any other bone. It is attended with extravasation of lood proportional to the amount of injury done to the brain tissue, and in evere cases this is sufficient to give rise to symptoms of compression which nask any special signs of cerebral laceration.

The regions of the brain most commonly injured are the anterior parts of he frontal and temporo-sphenoidal lobes. This is due partly to the irregu-arity of the surfaces of the bones against which these lobes lie, but much more o the fact that the posterior and postero-lateral parts of the skull and the ertex are the most exposed to injury from falls and blows. Thus when person slips suddenly in frosty weather and strikes the back of his head n the pavement, there may be no external sign of serious injury, nor any racture of the skull; yet laceration of the anterior portions of the cerebral emispheres frequently occurs at the point exactly opposite to that struck.

The explanation of this fact—that the chief laceration is opposite the point truck—is that the blow starts a wave in the soft cerebral substance which reaks against the bone on the other side. In very rare cases it is possible to race the course of this wave by hæmorrhages in the cerebral substance in ts track. Thus not long ago a case occurred in University College Hospital n which a man received a blow from a fall on the left side of the forehead. He lived ten days, and at the *post-mortem* examination a bruise of the brain was found in the frontal lobe at the point which first received the violence, and exactly opposite this on the right occipital lobe was another bruise; in a straight line between the two bruises was a hæmorrhage into the right optic halamus. Very sudden and violent blows, such as non-penetrating bullet-wounds, usually lacerate the brain immediately beneath the part of the skull truck, and some of the most typical cases of localized cortical injuries of the rain are consequently to be found in the records of military surgery.

The brain and its membranes are often lacerated by the *sharp spicula of a lepressed fracture,* which may penetrate to a considerable depth in its substance. And, lastly, the injury may be occasioned by *foreign bodies*, such as bullets, raversing or lodging in the head; by sabre or axe wounds, or by *stabs and unctures* through the inner portions of the skull, especially the orbital plate f the frontal bone. In this way a piece of stick, a tobacco-pipe, the point of knife, or a scissor-blade, may puncture the anterior part of the brain.

The effects produced by the passage of a bullet through the head require hort consideration. The experiments of Kocher have shown that the injury

produced by firing through an empty skull is limited more or less closely to the apertures of entry and exit. If, however, the contents of the skull be still within it, the sutures are at the same time widely torn open. This difference depends upon the so-called "hydrodynamic effect" of the bullet, viz., upon the passage of waves of increased pressure through the fluid contents of the skull at the moment when the bullet enters it. The experiments of Horsley and Kramer tend to show that in dogs these waves of pressure are of great importance in the production of sudden death from gunshot injuries of the brain. The pressure waves impinge upon the base of the brain, and by their effect upon the medulla cause sudden arrest of respiration. In these experiments prolonged artificial respiration usually succeeded in resuscitating the apparently lifeless animal. It is probable that the sudden death which occasionally follows a severe blow on the head, as by a cricket-ball, may be susceptible of a like explanation.

The **Post-mortem Appearances** of laceration of the brain vary with the degree of injury and the time the patient survives. In a recent case every stage may be met with, from a mere superficial bruise, marked by a few points of extravasated blood in the grey matter, which still maintains its natural form and consistence, to extensive laceration and crushing, in which the grey matter, and a greater or less amount of the white, is reduced to a pulpy, disintegrated mass, mixed with clots of blood. In the cases of simple bruising, there is no extravasation of blood in the neighbourhood of the injury; in severe laceration clots are found superficially adhering to the injured part of the brain, and extending widely in the subarachnoid space, sometimes completely covering one hemisphere with a thick layer of coagulum. Occasionally the extravasated blood may have forced its way into the substance of the brain, and even have burst into the lateral ventricle; but this is very rare.

In lacerations due to penetrating wounds or accompanying compound fractures in which the dura mater is torn, if the patient survive beyond the third day, marked inflammatory changes may be found at the injured spot. In these cases the brain substance is softer than natural in the area of laceration, and is readily washed away with a stream of water. At the injured part are the remains of the extravasated blood; round about it the brain substance is redder than natural. In addition to the local mischief, the whole brain usually presents the appearances indicating septic meningo-encephalitis; the pia mater is gorged with blood, and infiltrated with greenish, puriform, inflammatory exudation, starting from the injured spot and extending more or less widely in all directions; there is a slight excess of cerebro-spinal fluid in some cases, but in others the surface is almost dry, and the convolutions are slightly flattened from swelling of the brain; the grey matter is everywhere redder than natural, the red points seen in sections of the white substance are too numerous, and the ventricles often contain an excess of fluid.

In simple fractures, or in compound fractures in which asepsis has been maintained, the patient is not free from the danger of spreading mischief extending from the injured area. According to Bergmann the blood extravasated round the laceration is often sufficient in amount to press on the veins of the pia mater, and thus to cause a serious interference with the return of blood from the injured part. If the extravasation is small in amount there results but a limited area of œdema which soon disappears as the blood is absorbed and the pressure removed. But in extensive lacerations with more

abundant extravasation the swelling reaches a dangerous degree. Not only does it extend concentrically until it reaches uninjured and possibly vital parts of the brain, but the cerebro-spinal fluid becomes increased in amount by the transudation until it may give rise to fatal compression of the brain. The whole of this process is independent of true inflammation or infection from without, and is due to the anatomical arrangement of the vessels of the brain by which the blood returns chiefly through the large veins of the pia mater which are necessarily compressed by blood extravasated between them and the bone. In these cases a narrow zone, yellowish red in colour and dotted with points of extravasation, is found around the area of laceration: beyond this as far as the swelling extends the brain substance is moist, glistening, and softer than natural, that is to say highly œdematous.

Supposing the patient to have escaped these dangers, it is still possible that death may occur at a more remôte period from softening round the injured spot. This softening is a result of the interference with the circulation from the injury to the vessels and the consequent hæmorrhage, and possibly of local inflammation following the injury. As the effect of this, the brain tissue and any inflammatory exudation that may be present undergo fatty degeneration, forming a yellowish pulpy mass, which washes away readily under a stream of water, the condition being known as *yellow softening*. The microscope shows innumerable fatty granules and granular cells, with sometimes recognizable *débris* of the nerve-fibres of the white matter. It is possible that recovery may take place even after softening of an area of some size, the degenerated tissue being absorbed and a small superficial defect left in the surface of the brain.

In cases in which recovery takes place without these unhealthy changes, a small tough, opaque scar, depressed below the surface, is left in the cortex, to which the membranes become firmly adherent. In the centre of the cicatrix may be a darker patch containing crystals of hæmatoidin, indicating its hæmorrhagic origin. If much blood have been extravasated into the subarachnoid space, it occasionally happens that, instead of being completely absorbed, it becomes decolorized and partly organized, forming a layer, often of almost leathery consistence and of dirty brownish colour, which remains permanently adherent to one or both sides of the subarachnoid space. Occasionally it forms a complete cyst, flattened out in the space, and containing a trace of fluid. Such cysts are usually adherent to the dura mater, but have been found loose beneath the arachnoid.

Symptoms and Effects.—The symptoms and results of wound or laceration of the brain vary greatly according to the nature of the accident, the seat of the injury, the age of the patient, and other conditions which cannot always be very readily determined.

The ordinary symptoms of laceration of the brain are at first merely those of concussion already described (p. 743). As before stated, "concussion of the brain" is a clinical expression only, and probably in all cases in which the patient rallies slowly, and certainly in those in which a return of consciousness is delayed over twelve hours, there is more or less bruising and laceration of the cerebral substance. If, as the patient rallies, the symptoms of concussion gradually merge into those of compression (p. 745), within twelve or eighteen hours, we may be sure that this is due to hæmorrhage within the skull, either from a laceration of the brain or from wound of a meningeal artery or a

venous sinus. The diagnosis of this latter condition will be referred to further on (p. 767). If soon after the injury cerebral irritation (p. 745) sets in, we may be certain that aceration of the brain is present, probably in the frontal region. Violent convulsions occurring within twelve hours of an injury to the head are almost invariably due to hæmorrhage from a laceration of the brain, either tearing down the brain substance in the region of the motor centres or diffusing itself widely beneath the arachnoid. Lastly, impairment of function in any part of the brain with the function of which we are acquainted, occurring as the direct result of injury, may be looked upon as evidence of bruising or laceration of that part. On the second day the temperature rises to about 100° F. in all cases of laceration of the brain, and by the third day it is usually 101° F. or 102° F., even when the air is excluded from the injured part.

In many cases of lacerated brain the patient recovers after having regained consciousness without any further trouble than a fixed headache for some days or weeks over the injured spot. This is especially common when the laceration is in the frontal lobes. In cases of compound fracture with laceration, septic meningo-encephalitis is a frequent complication, though at the present time much less common than formerly owing to the more efficient treatment of the wound. Should this occur, the symptoms of this affection (p. 772) mask all those specially indicative of laceration. Even if the patient escapes this danger he is still liable to local inflammation possibly terminating in suppuration, or to spreading œdema (p. 750) round the injured area. These complications when they occur usually manifest themselves by definite signs from the third to the fifth day. If the lesion is not seated in the region of the cortical motor areas the only symptom may be increasing insensibility with gradual development of the signs of compression of the brain. If the region of the cortical motor centres is implicated, convulsions usually form a prominent feature of the case. These, though very alarming to the Surgeon and to the friends of the patient, are by no means to be looked upon as hopelessly fatal. If the fits are not accompanied by gradually spreading paralysis, and if consciousness returns between them, there is a good hope of recovery, especially if the patient be young and otherwise healthy.

Suppuration is a very rare complication of laceration without an open wound, but it is sometimes met with, coming on occasionally some weeks after the accident. It is indicated by elevation of temperature and a gradual increase in the disturbance of function—as spreading paralysis, loss of consciousness, and convulsions if the motor area is affected, with the special symptoms subsequently to be given in describing intracranial suppuration (p. 774).

The recovery after laceration of the brain is often incomplete, localised paralysis or permanent loss of some mental faculty not uncommonly remaining.

These being the general symptoms of laceration of the brain, it remains to be considered how they may be varied or modified by the nature of the injury and other circumstances.

The *Nature of the Injury*. If the brain be injured directly by some sharp-pointed or cutting instrument, as a sword or hatchet, the symptoms of concussion may be entirely wanting; the patient may not suffer from even momentary loss of consciousness. The same may occur when a blow with some angular body is received on the thin portions of the skull. Thus a young

man was admitted into University College Hospital suffering from an injury to the brain which caused aphasia and facial paralysis, received in a fall against some steps. In spite of the severity of the injury he did not lose consciousness, or, if he did, it was certainly for less than one minute. In punctured fractures the patient frequently walks to the hospital unconscious of having received any more serious injury than a cut head. It is not even uncommon to see a patient with a wound from which broken down fragments of brain substance are protruding, and who is yet perfectly conscious and has been insensible only for a few minutes. On the other hand, when the laceration is due to a more diffused blow on the head—in those cases in fact in which it is situated on the side opposite to that struck—concussion is almost always more or less distinctly marked. In these the injury is more diffused and seldom at first capable of accurate localization, for in addition to the local injury the whole brain has been more or less violently shaken. Under such circumstances, it is not surprising that the return of consciousness is often delayed for days or even weeks.

The *Locality of the Injury.* Until comparatively recently we had no means at our command by which we could with any certainty recognize the exact part of the brain which was bruised or lacerated by an accident unless the nature of the injury were such as to leave no doubt that the cerebral substance was wounded directly beneath the part of the skull to which the violence had been applied. It was known that injuries to one side of the brain caused paralysis of the opposite side of the body and face, and that sometimes the paralyses affected merely a part of one side, and were very temporary in their character; that in other cases extensive injuries of the brain were not accompanied by any interference with motor power; but there was no accurate knowledge by which the seat of the injury could even approximately be determined by the symptoms. The earliest definite attempt to localize an injury in the cerebral hemispheres was made by Broca, who pointed out in 1861 that the condition now known as aphasia, in which the patient loses the faculty of converting his ideas into articulate speech, is associated almost invariably with some definite lesion of the posterior part of the third left frontal convolution. As the result of the investigations of subsequent observers it has been clearly demonstrated that the cortical grey matter of the brain in the region of the sulcus of Rolando is the seat of various centres, which are connected with the voluntary muscular movements of the body. The means by which our knowledge on this subject has been gained have been experimental and clinical. Excitation of certain spots in this so-called "motor area" by a weak faradic current causes definite muscular movements. Destruction of these areas, on the other hand, is followed by a paralysis of the corresponding movements, although such paralysis may be more or less temporary. It appears indeed that each centre in the motor area corresponds with certain definite movements rather than with individual muscles. Hitzig and Ferrier showed that if the strength of the exciting current be increased the resulting movements are no longer accurately limited but extend to a whole limb or the whole side of the body: a still stronger current gives rise to a general epileptiform convulsion affecting the whole body and accompanied by loss of consciousness.

The accompanying figure (Fig. 304) represents the principal motor areas on the outer surface of the cerebral hemisphere of the Bonnet Monkey as determined by Beevor and Horsley. The exact limits of the different centres

are subject to individual variations, and to a certain extent adjacent centres overlap each other. The motor region extends from the outer surface of the hemisphere a short distance on to the corresponding part of the mesial aspect.

We must be cautious in transferring too readily the results of experiments upon the brain of animals, even of the higher apes, to that of man. Clinical experience in this subject is however ever increasing and tends more and

Fig. 304.—Outer Surface of Left Cerebral Hemisphere (Bonnet Monkey) showing the position of the Motor Areas. (Horsley and Beevor.)

more to confirm the view that the results produced by injuries of the cortex in the neighbourhood of the sulcus of Rolando are the same in the human subject as those following experimental injury of the corresponding parts in the lower animals. The evidence obtained by direct electrical excitation of the cerebral cortex in man is necessarily very scanty. The accompanying figure (Fig. 305), for which I am indebted to Victor Horsley, indicates the

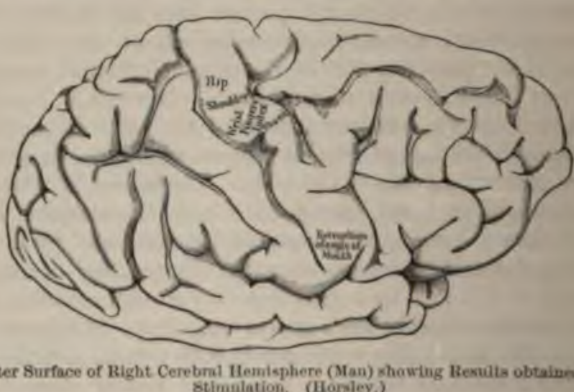

Fig. 305.—Outer Surface of Right Cerebral Hemisphere (Man) showing Results obtained by Electrical Stimulation. (Horsley.)

results of such excitations, and a comparison of Figs. 304 and 305 at once shews that these results are uniform in the two cases.

The symptoms produced by damage to the motor area of the cortex may be divided into primary and secondary, according as they are immediately induced at the time of the injury, or appear later as the result of inflammation or spreading œdema around the injured part. When, as the result of either

primary or secondary mischief, a distinct group of muscles is paralysed, the term "monoplegia" is applied to the condition; when a similar group is thrown into spasm, it is spoken of as "monospasm." Thus, if the upper limb alone is affected it would be described as brachial monoplegia, or monospasm, as the case might be. If a patient receive a blow upon the head, and, on his recovering consciousness, it is found that a localized paralysis is present, we conclude that there exists a laceration of some severity in the cortical centre corresponding to the muscles implicated. If almost immediately after the injury there is a distinct spasm, affecting a localized group of muscles, we conclude that hæmorrhage is going on from the lacerated brain substance, and irritating or breaking down the tissue of the centre corresponding to the affected muscles; if the monospasm extends, first affecting the whole side of the body and finally both sides, so that the attacks assume the form of true epileptic fits, it is probable that the extravasated blood is extending over the surface of the brain and irritating more or less widely the whole motor area. As shown by the experiments before mentioned, however, it is not necessary for both sides of the brain to be injured in order to produce a general spasm; a violent irritation at one spot only is sufficient. Consequently it is possible that such convulsions might be caused by hæmorrhage breaking down the brain tissue in a limited area. The convulsions in these cases usually assume a regular course; the fit commences by twitching of that part, which, in the intervals of the fits, is most clearly paralysed. Thus, in an injury in which the centre of the right side of the face is chiefly affected, and in which facial paralysis is well marked, the fit commences by twitching of the right side of the face, then the head is turned forcibly to that side, then the right arm enters into the spasm, then the right leg, after which the left leg, left arm and left side of the face are affected in the order mentioned. During the spasm the muscles of respiration become fixed, the face becomes livid, and the patient froths at the mouth as in a genuine epileptic fit. The attacks of convulsions often occur in rapid succession, and after each the paralysis may be found to have extended; the return to the normal state between the fits may become less and less perfect, and finally coma may set in. In such a case if coma is complete within twenty-four hours of the accident hæmorrhage from a laceration might be diagnosed with tolerable certainty, and the question of trephining might arise, the site of the operation being determined not by the situation of any external wound or bruise, but by the indications of cortica lesion furnished by the paralyses and spasms. It may happen, however, that the convulsions may not come on till the third, fourth or fifth day. They are then in some cases of compound fracture due to septic meningitis extending over the motor area. In cases without an open wound convulsions at this period are due to inflammatory hyperæmia or spreading œdema from interference with the circulation in the injured area (p. 750), extending round the injured spot. In favourable cases this frequently subsides, and the patient rocovers; but in others it goes on to such an extent as seriously to damage the brain substance, the convulsions increase in intensity and are repeated more frequently, the return to the normal state between the fits becomes less and less perfect, and finally coma sets in and death occurs. If the laceration be situated near, but not in the motor area, there may be no paralysis till after the convulsions, and the paralysis may then gradually extend after each convulsion, indicating the gradual spread of the mischief into the region of the

motor centres. In other cases again, the superficial motor centre may be affected at a much later period by the formation of an abscess in the substance of the brain. It is in these cases, perhaps, that the study of the localization of the functions of the cerebral hemispheres is of the greatest importance, enabling the Surgeon to determine the exact seat of the secondary lesion. In the primary lesion, the external injury of the scalp or skull will often suffice to lead the Surgeon to a correct conclusion as to the seat of the injury to the brain; but in secondary or consecutive disease, such guides may be entirely wanting.

The following is a short summary of the combined results of experimental, clinical, and pathological observations as applied to the human brain:

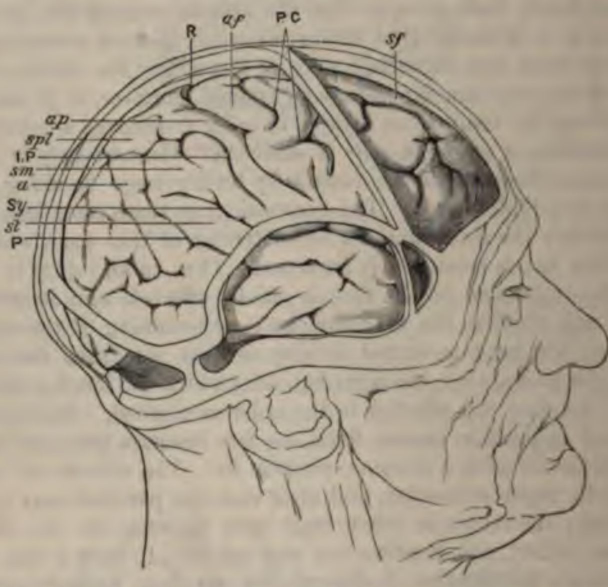

Fig. 306.—Cast of Head, showing the Convolutions of the Brain and their relations to the Skull. (From a preparation by Cunningham.) R, sulcus of Rolando; *Sy*, Sylvian fissure; P, parallel sulcus; I.P, intraparietal sulcus; P.C, precentral sulcus; *a.f*, ascending frontal gyrus; *a.p*, ascending parietal; *s.p.l*, superior parietal lobule; *a*, angular gyrus; *s.m*, supramarginal; *s.f*, superior frontal; *s.t*, superior temporal.

1. **Aphasia** is dependent on a lesion of the posterior extremity of the third or inferior frontal convolution of the left side—Broca's convolution.

2. **Facial Paralysis** depends on a lesion of the lower third of the ascending frontal convolution, and the contiguous part of the posterior end of the second frontal. The anterior part of this area is chiefly concerned in the movements of the upper part of the face. The posterior part, which extends to the lower third of the ascending parietal convolution, controls the movements of the lip and mouth. The fact that these centres are close to Broca's convolution, explains the frequent combination of facial palsy and aphasia.

3. **Paralysis of the Upper Limb** or brachial monoplegia indicates an affection of the middle portion of the ascending frontal convolution, and the contiguous part of the ascending parietal on the other side of the sulcus of

Rolando. This centre being immediately above those for the face, it is common to meet with a combination of facial palsy and paralysis of the arm.

4. **Paralysis of the Lower Limb** indicates a lesion of the upper extremity of the ascending parietal convolution, and of the posterior parietal lobule lying behind it, and reaching to the margin of the longitudinal fissure.

The above facts may be made more clear by a few typical cases.

In 1881, a young man, aged 20, was admitted into University College Hospital on the second day after he had received a rather violent blow on the left temple in a fall from some steps. On manipulating his head, a sensation was felt as if a small round piece of the thin part of the bone in that region had been broken loose; it was not depressed, and as further manipulation seemed dangerous, pressure was not repeated on it. He was not stunned by the accident, or at most for a few seconds only, but immediately lost the power of speech; he could understand what was said to him, and could say "yes," and "no," but nothing more. On the third day there was distinct paralysis of the lower facial muscles on the right side; on the fifth day, a clonic spasm commenced in the lower facial muscles, and gradually extended to the upper, and he lost consciousness. This lasted nearly half an hour, when he recovered, and was leeched over the injured spot, after which he fell into a sound sleep, and from that time rapidly improved, being practically well by the fifteenth day.

A gentleman, aged 39, was thrown from his horse, striking his head violently on the ground. He was taken up insensible, and was found to have a considerable extravasation in the right occipital region; there were no signs of fracture. He soon partially regained consciousness; he was quite unable to speak, and did not seem to recognize anyone, but from the first he got out of bed to make water, and showed signs of discomfort when he wanted to use the bed-pan. On the second day he was restless and his mental condition the same. On the fifth day, he could give the right or left hand when asked, though his mind was very far from clear; his speech was, however, evidently worse than the state of his mind could account for; he used only a few words, repeating them frequently; there was no paralysis. On the sixth day, he had violent convulsions, commencing with twitching of the right side of the face, followed by turning of the head to the right, a rigid spasm of the right arm, then of the leg; the spasm then became clonic and affected the left leg and arm, and finally the left side of the face. Between 10.30 A.M. and 2.30 P.M., he had twenty-one convulsions; his head was shaved, and he was leeched, and the convulsions ceased. The following day it was noticed that the right side of the face was paralysed. From this time his recovery was slow, but uninterrupted. It was many months before he regained the full use of words, and during that time he was haunted by an idea which he could not explain. Six months after, he had a violent epileptiform fit, preceded by aphasia, lasting some minutes, but he recovered without any evil consequences; he was suffering at the time from dyspepsia and constipation. On the first anniversary of his accident, he had a similar fit, and since that time several more have occurred at gradually increasing intervals. They have always been preceded by aphasia, lasting some time. On one occasion he signed an important cheque during the aphasic period, knowing the fit was coming on.

In the surgical history of the American war is recorded the case of a man who received a bullet wound which grazed the skull from the upper part of

the frontal region to the vertex. The right arm was immediately paralysed, at first only partially, but gradually the whole limb became powerless. Nine months after the wound he was, however, well enough to be returned to duty.

Guthrie records the case of a soldier, aged 40, who was wounded at Waterloo by a bullet, which passed across his head close to the vertex, fracturing and depressing both parietal bones. He was stunned by the blow, and when he recovered found he had lost power in both lower limbs. He was trephined ten days after the battle and made a good recovery, ultimately regaining much power in his legs.

These cases sufficiently illustrate the chief clinical features of injuries affecting the motor region of the cortex of the hemispheres. On each side of this motor region is an area the functions of which have not been defined with sufficient accuracy to be of much value in practical diagnosis. Considerable portions of the anterior parts of the frontal lobes may be lost without the patient showing any appreciable change either mentally or physically. It has already been seen, however, that those peculiar mental symptoms which occur in the condition known as Cerebral Irritation (p. 745) are almost certainly associated with bruising or laceration of this part of the brain. The sense of vision appears to be located in the occipital lobes; that of hearing in the temporal lobes, especially the superior convolution. The representation of general sensation in the cortex is little understood, but there is evidence to show that lesions of the so-called "motor areas" may result in tactile anæsthesia as well as paralysis.

As these cases of paralysis may require the use of the trephine, it is of great importance that we should be able clearly to answer the question whether the paralysis is dependent on central or cortical lesion. If due to compression or laceration of a central ganglion, it is obvious that the trephine would be useless. In these cases the paralysis will probably have been immediate, its completeness will be very marked, and the whole of one side of the body at least will in all probability suffer. In *cortical lesions*, in which the trephine may sometimes be advantageously applied, the paralysis, although it may be present immediately after the accident, often does not appear for some time; it is less complete and less extensive, sometimes affecting single groups of muscles, and is often preceded by convulsions.

The *Age of the Patient* has some influence on the symptoms and course of a case of laceration of the brain. Children, especially, have been known to bear extensive injuries of the brain, and even the loss of a considerable quantity of cerebral matter, without any very serious effects, either immediate or remote; and it is by no means uncommon to see them live several days with an extent of injury to the brain which would rapidly have proved fatal to an adult. Indeed it may be stated generally, that the younger the patient, the greater the chance of recovery. So, also, the prognosis may be considered more favourable in men of the labouring class, whose minds are but little exercised, than in persons of more cultivated intellect.

Foreign bodies even of large size and considerable weight have been lodged for a considerable time within the skull without causing death. Thus Hennen states that he has seen five cases in which bullets were lodged within the skull that did not prove immediately fatal. Cunningham relates the case of a boy who lived for twenty-four days with the breech of a pistol, weighing nine drachms, lying on the tentorium, and resting against the occipital bone.

O'Callaghan has recorded the remarkable case of an officer who lived about seven years with the breech of a fowling-piece, weighing three ounces, lodged in his forehead; the right hemisphere of the brain resting on the flat part, from which it was separated only by false membrane. Guthrie records two cases in which, although a ball had lodged in the brain, the patients apparently recovered. Both, however, died suddenly when drunk within a year after having received the wound. In one, who lived almost exactly a year, the bullet was found in a sort of cyst lying in the corpus callosum; in the other, who lived only a few months, it was lodged deeply in a cyst in the occipital lobe.

The **Diagnosis of Cerebral Laceration** varies much in difficulty, for, as before stated, the special symptoms indicative of laceration may be masked by those of compression or septic meningo-encephalitis. A careful consideration of the history and all the features of the case will, however, usually enable the Surgeon to come to a conclusion as to the presence of laceration; long continued insensibility without profound coma, convulsions, irregular and localized paralysis and spasms, are amongst the most important signs. Cerebral irritation may be looked upon as always indicating laceration. Some confusion may occasionally arise from the fact that the paralysis or convulsions resulting from a cerebral lesion are always manifested on the side of the body opposite to that on which the injury to the brain exists; but not necessarily opposite to that on which the blow has been inflicted on the head, for the injury to the brain may, by counter-stroke, be in that cerebral hemisphere which is opposite to the side of the head that has been struck. Thus, if a person struck on the right side of the head sustain a rupture of the middle meningeal artery, and have extravasation of blood on the right hemisphere of the brain, he may have hemiplegia on the left side, and *vice versâ*. But, if the blow that is inflicted on the right side gave rise to extravasation by counter-stroke on the left side of the head, the paralysis would develope itself on the side that had been struck. So it is with convulsive movements; they will occur in the arms and legs, on the side opposite to that on which the brain has been injured, whether that injury be on the side struck from direct violence, or on the opposite side from counter-stroke. In this way the hemiplegia may occur on one side, and the convulsions on the other. A man was struck a violent blow on the *right* temple. He was seized with hemiplegia and facial paralysis on the *left* side, and with convulsive movements of the *right* side of the face, the *right* arm and leg. He died a few days after the injury. On examination, we found a fissure of the right parietal bone, laceration of the middle meningeal artery, and a large clot pressing on the *right* side of the brain: hence the hemiplegia on the *left* side of the body. There was laceration of the middle lobe of the brain on the *left* side: hence the convulsive movements of the *right* side of the face, body, and limbs.

The **Prognosis** in wounds of the brain varies greatly according to the part that is injured, the nature of the injury, and the age of the patient. The danger is greatest and most immediate in injuries which affect the base of the brain, the pons, crura cerebri or medulla; it is least when the upper and anterior part of the hemispheres is the seat of lesion. Lacerations with open wounds, or compound fractures of the skull, or with penetration of a foreign body, are necessarily much more dangerous than those unaccompanied by such complications. Age has a very marked influence on the prognosis; the

younger the patient the more hopeful the case, other conditions being equal. The following may be looked upon as grave symptoms: early violent convulsions, extensive paralysis, and the rapid supervention of coma; a very high temperature with great restlessness. The later convulsions about the fifth day, although grave, are by no means hopeless symptoms; they become grave if they are frequently repeated, and if in the intervals there is found to be an extension of any paralysis that may be present, and especially if the condition of insensibility is found to be gradually deepening after each attack. When the symptoms of intracranial suppuration set in, the case, although desperate, is not quite hopeless.

Treatment.—In the treatment of injuries of the brain, little can be done after the patient has rallied from the shock, beyond attention to strict antiphlogistic treatment, though this need not be of a very active kind. In these cases, indeed, as much as possible should be left to Nature, the Surgeon merely removing all sources of irritation and excitement from his patient, and applying an antiseptic dressing when there is a wound.

If any foreign body be lodged in the skull, it must of course be removed, if possible. This may be done if it be situated near the external wound, or fixed in the bone; but if it have penetrated deeply into the substance of the brain, and have gone completely out of reach, it would perhaps be more dangerous to trephine the skull on the chance of reaching it, or in any other way to go in search of it, than to leave it where it is. Bullets should always be extracted if they can be found. On this point millitary Surgeons are agreed. If they enter the skull, and strike against and fracture the opposite side without escaping, should they be sought for? I think not. Larrey and Bell, it it true, have extracted the ball on the side of the head opposite the point of entrance. But it may not be found there. In a case of suicide to which I was called some years ago, a gentleman had shot himself through the right temple; immediately opposite the wound, on the left temple, was a raised, loose, and stellate fracture of the skull, over which the scalp was uninjured. I cut down on this and removed the fragments of bone, expecting to find the ball beneath them; but in this I was disappointed, and after death the bullet was found lying in the base of the skull, whither it had rolled. All operations performed in such cases should be carried out with strict antiseptic precautions.

In cases of laceration of the brain without open wound nothing is required at first beyond keeping the bowels open, applying cold to the head, and perfect quiet. Should there, however, be early convulsions or paralyses sufficiently definite to indicate the seat of the lesion, followed rapidly by coma evidently from its early occurrence due to hæmorrhage from a laceration, the question of trephining over the point of injury to the brain may arise. The indications for this operation are considered on page 771.

When the convulsions and paralyses occur at a later period, and are sufficiently defined to enable the Surgeon to localize the seat of the injury, the head should be shaved, and leeches applied over the seat of the laceration, and after this an ice-cap. If the pulse be full and hard, and the patient young, blood may also be taken from the arm. Venesection is especially likely to be of service if the symptoms be due to non-inflammatory spreading œdema (p. 750). The bowels should be freely acted on by some brisk purgative. Bromide of potassium should always be given in full doses as soon as convulsions appear.

A case showing the value of this occurred in University College Hospital a few years ago. The patient had typical symptoms of a lesion in the region of the centre for the right arm following a blow on the head. He was perfectly conscious and, beyond the weakness of the arm, showed no symptoms of any kind. About the fifth day epileptiform convulsions commenced; rapidly increasing in frequency and violence, and accompanied by gradual extension of the paralysis to the face and leg. It was evident that unless relief could be speedily given death was inevitable, and the question of trephining was discussed; but before doing so, bromide of potassium was given in full doses. The fits immediately ceased, and within a few days the patient, feeling perfectly well, insisted on leaving the hospital.

If in spite of these measures the convulsions become more violent and general, the paralysis more extensive, and the state of insensibility deeper, the question of treatment becomes more anxious. The extension of the mischief may be due to inflammation extending around the laceration, and in this case it is doubtful if much good could be hoped for from trephining. But on the other hand it may be the effect of non-inflammatory spreading œdema (p. 750), and under these circumstances the removal of the clot surrounding the laceration and the relief of tension by giving exit to the exuded fluid might be productive of the best results. At any rate, when other means have failed and the patient is evidently going from bad to worse, it is the Surgeon's duty to give him the last chance offered by trephining.

The operation is, however, more hopeful, and certainly should never be neglected when symptoms of intracranial suppuration supervene at a later period with localized paralysis sufficiently defined to indicate the part of the cortex affected.

The guide to the application of the trephine in these cases is the *line of the sulcus of Rolando on the side opposite to that in which the paralysis exists.*

It is thus essential that the Surgeon should be acquainted with a reliable method of ascertaining the position of this sulcus. The upper end of the sulcus of Rolando lies between one and a half and two inches behind the coronal suture, whilst the lower end is about one inch behind the same suture. Thane gives the following method for marking the position of the sulcus of Rolando and the fissure of Sylvius on the surface of the head (Fig. 307). A line (A B) is drawn from the infraorbital margin to the centre of the aperture of the ear, and parallel to this the line (C D) from the fronto-malar suture backwards. On this line mark a point (E) $1\frac{1}{4}$ inch from its commencement, and raise here a perpendicular $\frac{5}{8}$ inch long. The upper end of this line (Sy) may be called the *Sylvian point* and marks the place where the anterior branches are given off from the fissure of Sylvius. From the fronto-malar suture, draw a line through the Sylvian point to the parietal eminence; this lies over the posterior limb of the fissure of Sylvius. A point (iR) on this line 1 inch behind the Sylvian point is immediately below the lower end of the sulcus of Rolando. The upper end of the sulcus of Rolando (sR) is situated half an inch behind the mid-point between the root of the nose and the external occipital protuberance. A line drawn from sR to iR marks the position of the sulcus of Rolando, and forms with the median line anteriorly an angle of 70° or more. The parallel sulcus and the external parieto-occipital fissure are in a line (F L) drawn from the marginal tubercle of the malar bone to the lambda.

The position of the sulcus of Rolando having been defined on the head, the

exact point to which the trephine is applied must be determined by the seat of the paralysis.

Lucas-Championnière gives the following rules which indicate the point to be selected in the combinations of paralysis most commonly met with :—

1. When there is general hemiplegia the trephine should be applied over the middle of the line of the sulcus of Rolando.

2. When the arm and leg are paralysed, the trephine should be applied to the upper part of that line, but not at its very summit.

3. In paralysis of the upper limb only, the trephine should be applied a little in advance of the middle third of the line.

4. In simple aphasia it must be applied lower down, below and a little in front of the line.

5. When both lower extremities are paralysed, the top of the line and the vertex must be trephined.

6. When the upper and lower extremities are paralysed, the middle and upper part of the line should be trephined.

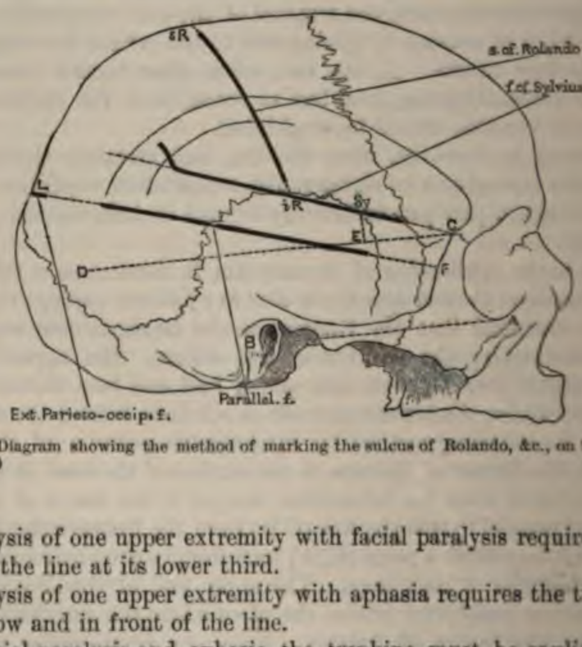

Fig. 307.—Diagram showing the method of marking the sulcus of Rolando, &c., on the surface of the head. (Thane.)

7. Paralysis of one upper extremity with facial paralysis requires trephining in front of the line at its lower third.

8. Paralysis of one upper extremity with aphasia requires the trephine to be applied below and in front of the line.

9. In facial paralysis and aphasia the trephine must be applied in front of the line and below its level.

In all cases a large trephine should be used, and if necessary it may be applied in more than one place.

Saccharine Diabetes is an occasional consequence of injuries of the brain. A man 43 years of age was admitted into the Hospital under my care with paralysis, the result of a fall on the back of his head. The urine was found to contain sugar in very large quantity. Previously to the accident, he had been perfectly well and robust; and, as the paralytic symptoms improved, the sugar lessened in quantity, until it disappeared, and this notwithstanding the continued use of saccharine and amylaceous matter in the food.

Claude Bernard has recorded some similar instances in illustration of the interesting facts pointed out by him, that in rabbits wounds or irritation of the central portion of the medulla, between the origins of the vagus and auditory nerves in the floor of the fourth ventricle occasion saccharine diabetes, and that in the dog artificial traumatic diabetes may be induced by fracture of the skull and injury of the brain. In patients already suffering from diabetes, a blow on the head is frequently followed by fatal aggravation of the complaint.

The **Cerebral Nerves** are occasionally injured at their roots, or torn across and detached from their connexion with the brain, in injuries of the head. These nerves may be wounded by the same violence that injures the brain, as by a bullet; or they may be detached from their connexion with the brain in laceration of the cerebral substance; or, lastly, they may be torn across in fracture of the base of the skull, by the fissure extending across the foramen through which the nerve passes.

From these causes, or from extravasation of blood into its sheath, blindness may result from injury to the optic nerve at any part of its course. Ptosis, and strabismus in different directions, according as the third, the fourth, or the sixth nerve has been injured, are also occasionally observed. But the nerves that most commonly suffer are the seventh and eighth, which are torn across in fractures of the petrous portion of the temporal bone, producing either paralysis of the face or deafness, or both together. Injury to the tenth nerve is not common, or rather it is rare for patients to survive who exhibit evidence of the lesion. I have, however, seen repeated vomiting, with palpitation, and a sense of suffocation continuing for months after apparent injury to the origins of the pneumogastric. In other cases, owing to lesion to the spinal accessory, spasm of the trapezius and sterno-mastoid muscles, simulating tetanus, may set in.

COMPLICATIONS OF WOUNDS OF THE BRAIN AND ITS MEMBRANES.

Extravasation of Blood within the Skull necessarily occurs in all injuries of the head accompanied by laceration of the brain, and in many in which the skull is fractured without wound of its contents. Indeed, when we reflect on the great vascularity of the parts within the skull, the large sinuses, the numerous arteries that ramify both within the bones and at the base of the brain, and the close vascular network extending over the surface of this organ, we can easily understand that extravasation of blood is one of the most frequent complications of these injuries and a common cause of death, when they terminate fatally at an early period after their infliction.

Causes.—Intracranial extravasation of blood may occur, as the direct result of a fracture, in consequence of the fissure tearing across one of the meningeal arteries, or of a fragment of bone wounding a sinus. In some cases the inner table only has been fractured, the middle meningeal artery being torn in this way where it lies in a groove in the bone. When the brain is lacerated either by the broken bone or by indirect violence, the torn substance necessarily bleeds more or less abundantly. In rare cases, especially in children, extravasation may result from apparently trifling injuries of the head without fracture, from rupture of one of the meningeal arteries.

Situations.—Extravasation may occur in four situations:—1. Between the

dura mater and the skull when it proceeds from a wounded meningeal artery, or more rarely, a sinus. 2. In the subdural space. 3. In the subarachnoid space and in the meshes of the pia mater on the surface of the brain; and 4. In the substance of the brain or in its ventricles. In the last three situations the blood is derived from the vessels of the pia mater, or the substance of the brain. Intracranial extravasation is most commonly met with on the surface of the brain from laceration of the cortex, but here it is seldom very abundant. It is much less common between the dura mater and the bone, but when occurring in this situation the quantity is often large, but even then seldom exceeds four ounces, although I have seen a clot from rupture of the middle meningeal artery weighing five ounces and a half.

Results.—The extravasation of blood into a closed cavity such as that of the cranium necessarily causes pressure on its contents, varying with the amount poured out. It is thus one of the most frequent causes of death in injuries of the head, giving rise to fatal compression of the brain and coma. In smaller amounts on the surface of the brain it may cause serious effects by interfering with the venous return from the injured area from which the hæmorrhage proceeded (p. 750). When of moderate amount it most frequently causes no evil consequences. The blood that is so extravasated may undergo various changes: 1. It may be absorbed entirely; 2. The serous portion, and a great part of the colouring matter, may be removed, leaving a fibrinous buff-coloured layer, which may occasionally become organized. This occurs only in arachnoid hæmorrhage. Such layers are sometimes double, and then, forming a flattened cyst, the cavity of which is merely moistened by a little fluid, are occasionally found unexpectedly in the subarachnoid space many years after the injury which gave rise to the extravasation; 3. The exterior of the clot may become consolidated, whilst the interior contains fluid and disintegrated blood. This occurs in the cerebral substance, and the cysts thus formed are permanent.

Symptoms.—The only definite symptom of extravasation of blood is gradually increasing insensibility, ending in coma within twenty-four hours of the injury. It is, however, a matter of the greatest practical importance to determine, if possible, whether the hæmorrhage is taking place between the dura mater and the bone, or whether it arises from a laceration of the brain substance, or is taking place into the membranes.

In a typical case of *Extravasation between the dura mater and the bone* there are three distinct stages: viz., concussion, a return and some continuance of consciousness, and then gradual supervention of coma. In exceptional cases in which the injury is very slight, more especially in children, concussion may not occur, and in a considerable proportion, the interval of consciousness between the concussion and the commencement of the symptoms is absent or very imperfectly marked. Jacobson, who has published a most exhaustive paper on this subject in the Guy's Hospital Reports, states that in 63 cases collected by him it was wanting in 21, and so little marked that it might easily have been overlooked in 10. The duration of the interval of consciousness is very variable, but it seldom extends beyond an hour or an hour and a half. The following cases illustrate these various conditions. A lady going into the opera stumbled on some stairs and struck the side of her head against the wall. She felt giddy and confused, returned home, went to bed, and was found comatose next day. I was sent for, but before

I could trephine she died. On examination, a four-ounce clot was found on the dura mater, under a ruptured meningeal artery, but without fracture. I have seen the same in a boy, who, running down stairs to his dinner, struck his head against the opposite wall; he ate his dinner, vomited, became drowsy and died. A large clot was found between the dura mater and the bone at the part struck. In neither of these cases was there any external bruise or other sign of injury. In a case of murder at Liverpool the man, after receiving the fatal blow, walked half a mile home, half a mile to see a medical man, and finally home again, and did not become unconscious for three hours and a quarter after the injury. In the cases in which the interval of consciousness is wanting, this is due either to very rapid hæmorrhage or to simultaneous laceration of the brain.

As the hæmorrhage takes place the symptoms of compression set in, and gradually increase in intensity. The extravasation being in the great majority of cases over the motor area of the cortex, paralysis is usually an early and important symptom. Most commonly, if the case be seen early, there is paralysis of the side opposite to the extravasation—in rare cases, more marked at first, perhaps, in one limb. As the pressure increases the paralysis usually becomes general, but even when this state is reached the thermometer in most cases shows that the temperature of the extremities is higher on the side opposite to the clot. Convulsions may occur early in the case but are not common. Vomiting is a very frequent symptom. In the early stages the patient becomes drowsy and dull, with a slow and labouring pulse, dilated and sluggish pupils, and a tendency to slow respiration. As the compression increases complete coma sets in with loud stertorous breathing.

When the symptoms follow the typical course with a distinct interval of consciousness we may feel tolerably sure that the extravasation results from injury of one of the meningeal arteries or large venous sinuses, and that there is no laceration of the substance of the brain; for it may safely be assumed that if the patient recovers consciousness after the accident, he cannot have such a degree of tearing and bruising of the cerebral substance as to lead to an escape of blood sufficient to cause compression. The vessel most commonly ruptured is the anterior branch of the middle meningeal artery, (Fig. 308*a*) which, from its situation in a deep groove in the parietal bone, is peculiarly apt to be torn in injuries of the side of the skull.

When this artery is the source of the blood, the clot extends deeply down into the base of the skull; and Hutchinson pointed out that in this way it may exert powerful pressure on the cavernous sinus, leading to fulness of the vessels, with protrusion of one eyeball and wide dilatation of the pupil. This occurs on the *same side* as the extravasation, and thus we may get hemiplegia of the opposite side, while the more dilated pupil is on the same side as the injury. It may, however, be pointed out, that in his experiments upon compression of the brain Dean found that under certain circumstances localized pressure on the cortex caused wide dilatation of the pupil on the same side. In cases complicated with a fissured fracture, some of the blood forces its way through the fissure, and thus may cause marked fulness of the temporal fossa on the affected side, clearly to be seen when the head has been shaved. A few years ago a man was admitted into University College Hospital who had fallen from the driving-seat of a van. He got up again and took

the reins, but feeling sick and giddy he left the box and lay down in the van, while his companion undertook to drive. About one hour afterwards he was found comatose. His head was shaved on admission, and on careful inspection a distinct fulness was noticed in the right temporal fossa, and on the parietal eminence of the same side was a bruise. He was trephined in the line of the artery and a large clot found and removed, but the brain failed to expand, and he died a few hours afterwards. In another case the patient fell eight or nine feet, and a quarter of an hour afterwards she came to the hospital. She was conscious, and related how the accident happened. There was a wound on the right side of the head, near the parietal eminence. She rapidly became unconscious, and two hours after the fall she was apparently dying. At this time the right eyeball was protruded, and the pupil widely dilated; the left was dilated, but less so than the right. She was trephined on the right side, and a large clot found and removed; the symptoms of compression were relieved, but she died eighteen hours after the accident. In both cases the brain was uninjured.

In some of these cases the respiration becomes greatly embarrassed, and this must always be looked upon as a grave symptom, indicating operative treatment.

The **mechanism of meningeal extravasation** has given rise to much discussion, and the following remarks of Sir Charles Bell ("Surgical Observations," London, 1816) are well worthy of attention :—"It is extraordinary that any one who has ever raised the skull-cap in dissection, and felt the strength of the universal adhesions of the dura mater to the lower surface of the bone, could for an instant believe that the *arteria meningea media* has power of throwing out its blood to the effect of tearing up these adhesions from the entire half of the cranium!" He then describes the following experiment to show that the dura mater is first of all separated from the skull, and that the extravasation is consequent on that separation :—"Strike the skull of the subject with a heavy mallet: on dissecting, you find the dura mater to be shaken from the skull at the part struck. Repeat the experiment on another subject, and inject the head minutely with size-injection, and you will find a *clot* of the injection lying betwixt the skull and dura mater at the part struck, and having an exact resemblance to the coagulum found after violent blows on the head. I imagine this is conclusive" (pp. 466—467). It is possible also that the alterations in form of the skull which accompany blows causing fracture see (p. 722) may tend to loosen the attachment of the dura mater. That the meningeal artery does, however, pour out blood with sufficient force to strip the dura mater further from the bone, when it is once loosened, can hardly be doubted, as it is difficult to conceive that that membrane can be shaken from the base of the skull by a blow on the parietal eminence; and yet meningeal extravasation often extends as far as the cavernous sinus. It must not be forgotten that when once a cavity is formed, the blood forced in acts on the principle of the hydraulic press. Taking the pressure in the artery to be about two pounds to the square inch, when four square inches of dura mater are separated we have a force of eight pounds pressing against it; when it is separated for three inches in each direction the pressure equals eighteen pounds. To resist this we have only the adhesion of the dura mater and the blood-pressure in the capillaries of the brain substance. It is not surprising, therefore, that the force exerted by the escaping blood produces such marked effects.

Extravasation of blood into the membranes may occur with little or no bruising of the brain substance itself. The amount of blood extravasated may be considerable, so that a layer of varying thickness is found over a large part of one or both hemispheres, whilst the remainder gravitates towards the base. Under these circumstances the symptoms of compression may speedily develope, and are not preceded by that distinct interval of consciousness which is so common in cases of hæmorrhage outside the dura mater. But on the other hand the development of coma is likely to be less rapid than is the case when the blood is derived from lacerated brain substance. Localized extravasation of blood into the membranes is not necessarily accompanied by the symptoms of general compression. If it occur over the motor areas the irritation produced by its pressure on the brain is likely to result in convulsions followed by paralysis, the distribution of which may serve as an indication of the seat of the lesion.

The extravasation of blood dependent on laceration of a portion of the brain may be termed *Cerebral Extravasation.* It is far more common than the other forms: in it the patient never recovers consciousness after having been stunned, the symptoms of concussion speedily passing into those of compression. In these cases the paralysis is commonly incomplete, often hemiplegic, and is associated with twitching of the limbs or convulsive movements of the body generally, and much restlessness with incoherent muttering: the pupils are sometimes contracted, sometimes dilated, and occasionally squinting is observed.

Diagnosis.—The diagnosis of these forms of extravasation is important, as it is in the extra-dural variety especially that operative procedure is likely to be attended with success. It can, however, be made with any degree of certainty only when the typical symptom of the interval of consciousness is present. When the different forms occur together accurate diagnosis becomes almost impossible. If the interval of consciousness is absent, the protrusion of the eye with dilatation of the pupil on the same side as the injury, the fulness in one temporal region and the difference of temperature in the two axillæ, may indicate the nature of the case. In doubtful cases the Surgeon should cut down on the skull in the region of the meningeal artery and examine for fracture.

The diagnosis between the compression from *extravasation* and that from *depressed bone* or *inflammatory effusions within the skull* is easily made. In the case of depressed fracture, the symptoms of compression continue uninterruptedly from the very first, and proper examination of the skull will always lead to the detection of the injured bone. When inflammatory effusions exercise undue pressure upon the brain, the signs of compression come on at a later period and are preceded by symptoms of cerebral inflammation, accompanied by a good deal of pyrexia, quick pulse and hot skin.

From *apoplexy*, the diagnosis is not always easily made, more particularly when there is no evidence that the head has been injured. I could give numerous instances of this. The following will suffice :—A man was brought to University College Hospital in a state of profound coma, in which condition he had been found lying in the street. There was no evidence of injury about the head beyond a bruise, which had probably been received when he fell. The case, which was supposed to be one of apoplexy, and was treated accordingly, proved fatal in a few hours. On examination after death the skull was found

fractured, but not depressed. On the side opposite to the bruise and fracture, a coagulum, weighing nearly four ounces and compressing the brain, lay between the dura mater and the bone. In such a case, it is evident that the history can alone afford a clue to its true nature. Even when the head has been injured, the diagnosis is not always easy. A man was admitted under my care, comatose. A fortnight previously he had been struck on the left side of the head behind the ear. He was stunned, bled freely from the left ear, but then recovered tolerably, and went about his avocations as usual until the day before his admission, when he suddenly became comatose. The respiration was stertorous, the pulse quick, and there was some heat of head; the right pupil was natural, the left contracted. He was treated antiphlogistically, but died on the third day. On examination, a fracture on the left side of the skull was found, extending into the left internal meatus; on the right side of the head there was a large coagulum in the subarachnoid space, with some sero-plastic exudation about it. Here was an extravasation, the result of laceration, existing without symptoms for fourteen days, and then proving rather suddenly fatal in consequence of the supervention of inflammation. A woman fell in the street whilst walking. She was taken up insensible; was thought to have a fit; became comatose, hemiplegic on the right side, and died the next day. After death the left parietal bone was found to be fractured, and a clot which weighed five and a half ounces was lying over the ruptured middle meningeal artery on the dura mater.

The insensibility of *drunkenness* may usually be distinguished from the coma resulting from injuries of the head, by the absence of local mischief, by the smell of the breath, and by the face of the drunkard being flushed and turgid, and not pale like that of a person who is suffering from the effects of a severe injury. When a drunken person has met with an injury of the head and is insensible, he should always be carefully watched, however slight the injury may appear to be, until sufficient time has elapsed for him to recover from his drunken fit, as it is impossible to say whether the stupor be the result of intoxication, or of mischief within the skull. I have known cases to be sent away from hospitals as drunk, when in reality the stupor was occasioned by depressed bone.

In the stupor from *poisoning by opium*, the condition of the pupils, which are contracted to the size of a pin's point, instead of being widely dilated as in coma from cerebral compression, will enable the Surgeon to make the diagnosis.

In considering the question of the **Treatment** of extravasation of blood within the skull, we must, as far as possible, define the conditions in which it may be hoped that the application of the trephine may give relief. The only alternative consists in the adoption of general and local measures, having for their object the arrest of further hæmorrhage, the promotion of absorption, and the prevention of inflammation.

If the *symptoms point with tolerable certainty to meningeal extravasation between the dura mater and the bone*, probably from the middle meningeal artery, the Surgeon should cut down at once upon the skull and examine the bone and trephine in the line of the fracture if one be found; if not, in the line of the middle meningeal artery. The artery may be wounded at any part of its course within the skull, but it is very rare for the main trunk to be ruptured; almost invariably it is the anterior branch that suffers. This branch is first directed forwards across the great wing of the sphenoid to near

the tip of the small wing: here it takes a sharp curve backwards, and often enters a canal in the bone; from this point it is directed backwards and upwards in the groove which crosses the anterior inferior angle of the parietal bone (Fig. 308). Its course may be found externally by the following rule:— Draw a straight line (A, B) backwards from the external angular process of the frontal bone; take a point (C) at any distance between one inch and two and a half inches from the angular process in this line and draw a vertical line (D, E) through it from the zygoma; measure a corresponding distance up this line, and the point so found (M) will be over the artery. If the distance taken be under one inch and a half, the artery will very frequently be found in a canal in the bone; beyond this it is usually in a groove. Accuracy is of importance only when a fissured fracture is found, as the centre of the crown

Fig. 308.—Relations of the Middle Meningeal Artery and Lateral Sinus to the surface of the Skull. M, meningeal artery, with *a*, anterior, and *p*, posterior branches; *l.s*, lateral sinus; *m*, mastoid vein.

of the trephine should, if possible, be at the point at which the fissure crosses the line of the artery. In other cases a very sufficient and practical guide is to put the pin of the trephine two and a half inches vertically above the condyle of the lower jaw.

The bone should be exposed by a semicircular incision around the spot to which the trephine is to be applied. This incision divides the scalp and the temporal aponeurosis and muscle. A large branch of the superficial and one or both deep temporal arteries will require ligature. The flap, together with the periosteum, is turned downwards from the bone with an elevator, and the crown of a large trephine applied, with the pin of the instrument over the spot where the vessel is supposed to lie. If the diagnosis have been correct, as soon as the circle of bone is removed a dark solid clot pushes its way up into the opening. As a rule, however, it is too solid to come out without the use of a scoop, and for this purpose a small lithotomy scoop may be used. The Surgeon, having now trephined and removed the blood-clot, is confronted with what is truly the greatest difficulty of the case. The artery in the majority of cases follows the dura mater, for it is only if it be in a canal in the bone that it remains superficial. If the brain expands as soon as the pressure is removed, the injured artery may come into view; if not, all that is

seen is a profuse flow of blood pouring out of the opening in the skull, and apparently in some cases threatening to be almost immediately fatal. Under these circumstances all that can be done is to raise the patient into a sitting position, to compress the carotid, and to apply ice to the side of the head and neck. Under this treatment the bleeding usually ceases rapidly and does not recur. If the actual wounded spot can be seen, a fine catgut or carbolized silk ligature must be passed round it with a sharp needle. If the artery lie in a canal, and its torn end can be seen bleeding where the trephine has cut through it, the hæmorrhage may be arrested by inserting a small plug or by touching it with the cautery. If the situation of the wound can be recognised at some distance from the trephine opening, more bone may be cut away either upwards or downwards so as to expose it. The operation should, of course, be performed with the strictest antiseptic precautions.

In some cases the hæmorrhage is due to the tearing of a large number of small vessels, and not to the wound of any special branch. Thus, in one of the fatal cases in University College Hospital, a child, aged seven, the most careful examination failed to detect any wounded artery. The hæmorrhage was in this case situated behind the region of the large branches of the meningeal artery, and the clot was reached by cutting away a portion of the skull behind the trephine hole with bone-forceps.

The instances in which the symptoms are sufficiently definite to guide the Surgeon with precision to a wounded meningeal artery are not numerous. Out of many hundred cases of serious and fatal injury to the head that were admitted into University College Hospital during the time I had charge of wards in that institution, in four cases only, I believe, was it found advisable to have recourse to trephining for the removal of extravasated blood. In three of these cases death speedily ensued, the coma being unrelieved by the operation. In the fourth case, recovery took place. This case was that of a man admitted comatose, three days after receiving an injury of the head by a fall from a cab. There were no serious symptoms for some hours after the accident; but then stupor gradually came on, amounting at last to complete coma. On examination, a bruise of the scalp was found on the left temple; through this I made an incision, and, finding a starred fracture over the sinus of the middle meningeal artery, trephined the bone, when a large coagulum was found lying upon the dura mater, and, on removing this, fluid arterial blood freely welled up. The coma was relieved, and the patient made a good recovery.

From 1870 to 1881 four cases were trephined in University College Hospital for meningeal hæmorrhage; three by Beck, all of which terminated fatally, and one by Godlee, which was successful. In this case the bleeding artery was seen and secured by a ligature.

In cases *in which the diagnosis of middle meningeal hæmorrhage cannot be made* the indications for trephining are not so clear. If the signs are those of general compression, without any localizing symptoms, it is certain that operation can do little if anything to relieve them. The effused blood is, under these circumstances, usually most abundant about the base of the brain, which cannot be reached by any operation; and, even if it be situated chiefly over the convexity of the hemispheres, the Surgeon has no guide for the application of the trephine, and no means of removing the blood which spreads widely in every direction.

In other cases, however, as we have seen, careful observation of the convulsions or paralyses which supervene may indicate the position of the extravasation. If, under these circumstances, the extension of the motor phenomena shows that the hæmorrhage is continuing, or if signs of general compression, especially deepening coma, develope, the Surgeon should lose no time in applying the trephine over the spot indicated by the symptoms.

Even with the strictest antiseptic precautions the operation, which necessarily involves opening the dura mater, is a serious one. It should not be undertaken as an immediate means of treatment, if the general symptoms of compression be absent, and if the local symptoms be not progressive. But at a later period trephining may be required with the object of relieving persistent paralysis or signs of irritation. The hope of a successful result is necessarily greater when the effusion of blood is in the subdural space than when it proceeds from lacerated brain substance. Of the several cases of this kind in which the application of the trephine has been guided entirely by the symptoms, one of the most striking is recorded by Macewen. A boy, after a fall on the head, had for six days been subject to convulsions beginning in the left side of the face and spreading to the left arm and leg. There was also paresis of the same parts. The trephine was applied over the lower end of the right sulcus of Rolando, and two ounces of blood-clot were evacuated from the subdural space. The recovery of the patient was complete.

If it be decided that no operation is advisable, the head must be shaved and ice applied, and the patient kept at perfect rest. If the respiration and pulse become much embarrassed, free venesection may give some relief.

TRAUMATIC MENINGITIS AND ENCEPHALITIS.

Acute diffuse meningitis — Acute Lepto-meningitis — Meningo-encephalitis.—Inflammation of the brain and its membranes from injury is a complication of great frequency and of corresponding importance.

Causes.—Every wound or laceration of the brain must necessarily be followed by a localized traumatic inflammation in the injured area, but there is no greater tendency for this to spread or to persist in the brain than in any other part of the body. Its natural course is to subside and to give place to the normal processes of repair in from twenty-four to forty-eight hours. If the inflammation extends or persists it is due to some source of irritation, other than the wound, introduced subsequently to its infliction. It is extremely rare to find meningitis following simple injuries of the head, however severe, in which there is no wound of the skin or fracture of the skull. When such a condition is met with it is most commonly due to general infection from some unhealthy wound in another part of the body inflicted at the same time as the injury to the head. In unhealthy children diffuse meningitis may follow a simple injury in rare cases, just as diffuse infective periostitis may follow a blow on a bone, the source of infection in these cases often remaining uncertain. Acute meningitis, after open wounds of the head, is almost invariably of septic origin. It is needless to explain how readily infection occurs in open fractures with wound of the dura mater, unless special precautions are taken to prevent it. In compound fractures, in which the dura mater is intact, it occurs less frequently, but is by no means uncommon and is

a frequent cause of death after fracture of the base of the skull. In these cases the septic matter doubtless finds its way through the dura mater by means of the lymphatics, for Schwalbe has shown that fluids injected between the dura mater and the bone pass readily into the subdural space. In cases of scalp wound, with exposure of the bone, meningitis may be set up as a consequence of necrosis or diffuse inflammation of the diploë (p. 718), or according to Schwalbe it may occur even without this, as he showed that fluids injected between the pericranium and the bone, especially in the neighbourhood of the sagittal suture, found their way by the lymphatics to the outer surface of the dura mater. In other cases the meningitis has been a consequence of septic thrombosis of the sinuses of the dura mater which has subsequently extended to the veins of the pia mater. Lastly, the septic matter may find its way along a nerve to the membranes, as in some cases of wound of the orbit and in fracture of the base of the skull with exposure or rupture of the facial or auditory nerve.

Period of Invasion.—Septic meningitis, following compound fractures of the skull, usually manifests itself on the second or third day, when the septic processes are well established in the wound. In cases in which the bone is exposed without fracture it may occur at any time until the wound is healed, but it is most common during the second and third weeks after the injury. In the rare cases in which it is said to have followed simple laceration without external wound it has usually been the result of drunkenness or exposure before the injury to the brain was soundly healed.

Pathological Changes.—After death we usually find on raising the dura mater that the brain is somewhat swollen, its convolutions being more or less flattened. The surface is generally dry, though there is frequently an excess of fluid in the ventricles. The characteristic feature of meningitis is the presence of greenish-yellow lymph, often almost purulent in character, lying partly in the subdural space and partly in the meshes of the pia mater. It is most abundant in the neighbourhood of the injury. The pia mater is intensely injected, and the sinuses are distended with blood. The cerebral substance is always affected with the membranes covering it, and therefore this condition is sometimes spoken of as meningo-encephalitis. The brain substance, when cut into, exhibits an increase in the number of red points; the grey matter is darker than natural, and often distinctly reddish in tint. If there is a laceration of the brain, the cerebral substance round it is usually softened, washing away with unnatural readiness under a stream of water.

The **Symptoms** usually commence within forty-eight hours of the infliction of the injury. The patient, if he is conscious at the time, complains of severe, constant, and increasing pain in his head; the scalp is hot, the carotids beat forcibly, the pupils are contracted, the eyes intolerant of light and the ears of noise; the pulse is full, vibrating, and bounding: and wakefulness, with delirium, commonly of a violent character, speedily comes on. All the symptoms of severe pyrexia set in at the same time. The temperature rises rapidly, usually reaching 103° F., or more, by the third day.

Under proper treatment, this condition may gradually subside until the health is re-established, but more commonly the symptoms of inflammation merge into those of compression—the delirium being replaced partly or

entirely by stupor, from which the patient is roused with difficulty, the pupils gradually dilating, the breathing becoming heavy and stertorous, the pulse sometimes continuing with its former rapidity, at others becoming slow and oppressed. The skin is hot but clammy; the patient falls into a heavy, dull, unconscious state, which alternates with convulsive twitchings or jerkings and occasional delirious outbreaks. As death approaches, the sphincters relax, the pulse becomes slower and more feeble, the surface cooler, the coma more intense and continuous, until the patient sinks from exhaustion and compression conjoined.

Diagnosis.—Acute meningitis is distinguished from pressure of extravasated blood by the later time at which it appears, by the elevation of temperature and the quick pulse. From spreading œdema (p. 750) extending round a laceration it is recognized by the presence of fever, but the distinction is not always easily made.

Treatment.—The preventive treatment is of the greatest importance, for when the symptoms of acute meningitis have set in, the patient seldom recovers, whatever may be done for him. The most scrupulous attention to the prevention of decomposition in all cases of wound of the scalp or compound fracture is the most efficient means at our command for the prevention of meningitis. Should the symptoms manifest themselves, active treatment should at once be adopted. The head must be shaved, and cold applied. In the use of cold, great care must be taken that the application is constant; intermittent cold is worse than useless. One of the best modes of application is the india-rubber ice-cap, which can be secured to the head by a strap passing under the chin; or Leiter's soft metal tubing, which can be moulded to any form, and through which a stream of cold water is kept constantly flowing, is even more efficient. Should these not be available, a bladder filled with ice may be used, but care must be taken that it is firmly secured in its position by bandages, and not, as is too often done, allowed merely to lie against the head, so that it is displaced by the slightest movement of the patient. A mackintosh cloth must be placed beneath it to protect the bed-clothes from being wetted. Bleeding from the arm, repeated as often as the pulse rises, as well as cupping, or leeches, may be had recourse to; the bowels should be freely opened, and rigid abstinence must be enjoined, the patient at the same time being confined to a quiet and darkened room, and removed from all causes of excitement of the special senses.

Chronic or Subacute Encephalitis is a most interesting and important affection following injuries of the head. Its pathology is not very clearly understood. In some cases after death the arachnoid is found opaque and thickened. In other cases the symptoms have been due to chronic inflammatory changes, or softening taking place round the site of a severe cortical laceration. The symptoms may come on within a few days of the injury or not until months have elapsed. The patient in many cases has apparently recovered entirely from the accident, though in others it will be found that some one symptom indicative of the brooding mischief still continues, such as headache, or impairment of sight or of hearing. Occasionally, the coming mischief is foreshadowed by unusual irritability of temper, by loss of mental vigour, or by some other functional disturbance of the brain. In such cases the subacute encephalitis may suddenly come on, ushered in perhaps by an aggravation of the persistent symptom, or by an epileptic fit. The sub-

sequent symptoms are very variable. There is usually pain in the head with heat of the scalp and irregularity of the pupils or contraction of both. There may be squinting, intolerance of light, convulsive twitchings, or epileptiform fits. At the end signs of compression may set in, terminating in coma. There may be a slight persistent elevation of temperature when the symptoms become pronounced. This affection is most dangerous and unmanageable, being very apt to terminate in loss or impairment of the senses, in diminution of intellectual power, or in local paralysis. The best results are obtained by the proper administration of mercury and the employment of counter-irritants. The best mode of administering the mercury is to give half a grain or a grain of calomel every four or six hours until the gums are affected, and to keep up the effect with diminished doses of the drug. The repeated application of blisters over the shaven scalp is perhaps the most useful form of counter-irritation. So long as any symptoms of inflammation continue, this plan of treatment must be steadily kept up.

In the more chronic forms of cerebral irritation following injury, more especially if there be any tendency to convulsive movements, bromide of potassium in moderate doses will be found of essential service. It soothes and secures sleep more effectually than any other remedy.

INTRACRANIAL SUPPURATION following injury may occur in three situations: (*a*) Between the bone and the dura mater; (*b*) in the membranes; and (*c*) in the brain itself. In the large majority of cases the suppuration is the result of the direct infection of the interior of the skull by pyogenic organisms which gain an entry at the seat of injury. Exceptions to this rule are apparently presented by those rare cases in which an abscess developes in the brain substance opposite the point struck, and possibly by recorded instances of intracranial suppuration, the result of injury without an open wound. The nature of the injury itself differs widely. In not a few cases suppuration has followed a wound of the scalp, exposing the bone, but not fracturing it. Under these circumstances it is probable that septic phlebitis occurs in the diploë, and that thence the infective process spreads inwards along the small blood vessels. More frequently, however, the bone is fractured, and thus a ready entry for pyogenic organisms afforded. Punctured fractures are especially likely to be followed by intracranial suppuration. In such cases the brain may be directly infected at the time of injury; but, apart from this, suppuration is favoured by the splintering of the inner table, and the accumulation of blood on the inner surface of the bone, as well as by the imperfect escape for the discharge afforded by the small size of the external wound. Macewen points out that extensive compound fractures are less dangerous in this respect, as they allow a free exit for discharges, whilst being obviously serious they are likely to be more efficiently treated. The danger of the punctured fracture lies in its apparent simplicity. A cerebral abscess may be occasioned by the lodgment of a foreign body, such as a bullet, in the brain substance.

a. **Subcranial Abscess** forms between the bone and the dura mater. It occurs beneath the seat of injury, and is the result of infection from a scalp wound, with or without fracture. It usually occurs early, before the wound has healed, but an interval of several weeks may elapse and the scalp wound may be healed before the symptoms of intracranial suppuration manifest themselves. Subcranial abscess necessarily involves a localized inflammation

of the dura mater, and is not unfrequently a precursor of septic meningitis or cerebral abscess.

The *symptoms* of this condition are in many respects similar to those resulting from suppuration in other situations within the skull. They were first described by Percival Pott. There is heat of head with throbbing carotids and flushed face. These symptoms are accompanied by elevation of temperature, headache, intolerance of light and noise, and drowsiness.

Delirium and vomiting are occasionally observed. During the continuance of these symptoms fits of shivering or actual rigors may occur. If the scalp wound be still open, as is commonly the case, it is found dry, whilst the pericranium is separated from the bone, and the latter is yellowish brown and dry, or in a condition of necrosis. If however the wound be closed or scabbed over, the scar and surrounding scalp will be found to be raised into a soft œdematous swelling—Pott's "*puffy tumour*."

b. **Intrameningeal Abscess** is merely an exaggeration of the septic meningitis already described. It may be the result of the extension of an abscess between the bone and the dura mater, or on the other hand it may complicate an abscess in the brain substance. Occasionally it is met with as a result of pyæmia arising from some other injury complicating that of the brain.

The *symptoms* are those of acute septic meningitis already described (p. 772), and the diagnosis of the localized abscess can rarely be made.

c. **Cerebral Abscess** is met with in an acute or chronic form.

In the *acute* form the abscess usually forms close to the surface of the brain at the point of injury. It is often accompanied by suppuration in one or both of the other situations already mentioned, the symptoms of which may completely mask those due to the cerebral abscess itself.

A *chronic* or *subacute* abscess is almost exclusively met with after wounds of the scalp exposing the bone, with or without fracture of one or both tables. It has been said to occur after simple blows not wounding the scalp, but the evidence of this is not very satisfactory. The abscess is seated deeply beneath the cortex somewhere in the lobe of the brain corresponding to the part of the skull injured. There is no evidence that it is in any way due to bruise or laceration of the brain substance, as this always affects the cortex and not the white matter. These abscesses are exactly analogous to those which are not uncommonly met with as a consequence of chronic suppurative inflammation of the middle ear. The exact mode of formation is somewhat uncertain, but it is believed to be due to a limited septic thrombosis and phlebitis extending from the injured spot into the brain substance.

The *Symptoms* of cerebral abscess necessarily vary according to whether it occurs as an acute form situated near the surface of the brain at the seat of injury, or as a chronic form deeply seated in the white matter. In the former case the early symptoms are likely to be those already described as following suppuration between the bone and the dura mater, and indeed this condition is often present. Drowsiness is followed by insensibility, deepening into coma.

In the more chronic form, which may occur after a long interval, the symptoms are exactly similar to those produced by the cerebral abscess following chronic suppuration of the middle ear (Vol. II., Chap. LV.). Among them may especially be mentioned headache, vomiting, slow and full pulse, subnormal temperature, optic neuritis, and drowsiness deepening into

coma. In some cases the puffy swelling of the scalp already referred to may be observed.

In determining the probable position of the abscess the Surgeon may be assisted by the seat of the injury and by the presence of certain localizing symptoms. The abscess is usually found beneath the seat of injury, and the earlier it occurs the greater is the probability of this being its position. If however the abscess is situated in the region of the cortical motor centres the affection of these, with gradually spreading paralysis of the opposite side, may serve as a valuable means of localization. As early as 1876 Macewen successfully diagnosed the position of a cerebral abscess by the symptoms produced. A boy, eleven years of age, manifested symptoms of intracranial suppuration after a scalp wound in the left frontal region. On the twenty-sixth day a convulsion occurred, beginning in the right side of the face and spreading to the right arm and leg. This was followed by aphasia of one hour's duration, and right hemiplegia, which remained pronounced for several hours. A diagnosis was made of "abscess in the immediate vicinity of Broca's lobe, situated between the speech centre and the internal capsule." The parents of the boy refused to permit operation, but the diagnosis was confirmed by *post-mortem* trephining.

In one recorded case the position of the abscess in the occipital lobe was recognised by the presence of hemianopsia. In the frontal lobes especially, a large abscess may exist without localizing symptoms. The presence of optic neuritis is of no value in determining the position of a suspected abscess, nor does the absence of optic neuritis negative the diagnosis of abscess if the other symptoms be well marked.

Symptoms of lepto-meningitis may result from the extension of the abscess to the surface of the brain and the infection of the membranes; whilst the sudden onset of complete coma with weak pulse and respiration, dilated pupils, and muscular rigidities may be due to the bursting of the abscess into one of the lateral ventricles.

Diagnosis.—The acute form can rarely be distinguished from ordinary septic meningitis without an abscess. The chronic or subacute form can be diagnosed only by attention to the symptoms above given. It may, in many cases, somewhat resemble pyæmia, also a not uncommon complication of scalp wounds exposing the bone. Pyæmia can usually be recognised by the repetition of the rigors, the characteristic temperature, the absence of any signs of pressure on the brain, and the occurrence of local suppurations in other parts of the body.

Cerebral abscesses, either single or multiple, may occur as a consequence of pyæmic infection from any unhealthy wound, and conversely a case of cerebral abscess may be complicated by pyæmia secondary to it. In these cases accurate diagnosis is impossible.

The **Prognosis** of all cases of intracranial suppuration is almost hopeless if untreated. The only form in which recovery may occur without surgical interference is that in which acute suppuration occurs beneath a compound fracture with loss of bone. In these cases the pus may discharge itself through the wound and recovery may follow.

Treatment.—The preventive treatment of intracranial suppuration consists in efficient antiseptic treatment of any wound of the head. If this fails, exit must be given to the pus in some way, or the patient will die. In cases

of acute suppuration in compound depressed fractures or punctured fractures, if no primary operation has been performed, the bone should at once be exposed and the fragments elevated or removed and, if necessary, the opening enlarged with the trephine or chisel. This gives the patient his only chance, but if the case is complicated by septic meningitis the chance is but small.

In the chronic and subacute cases following injury with exposure of the bone the Surgeon's duty is equally clear. He should expose the bone thoroughly, and if he finds it bare, yellowish in colour and possibly necrosed, he should at once remove a circle of bone with a large trephine. The operation, if carefully performed, can do no harm, and, if pus has formed, it offers the only chance of saving life. If pus be found beneath the bone the cavity in which it lay should be cleaned out with some efficient antiseptic fluid and dusted with iodoform, after which the wound may be loosely closed, perfect provision being made for drainage, and an antiseptic dressing of some kind applied. The dura mater should be carefully examined, and if a small aperture be found in it this may be enlarged to facilitate drainage.

If the pus is immediately beneath the dura mater that membrane will be dull yellowish in colour, and will bulge into the wound, without pulsation. Under these circumstances an incision must be made through it. If pus is reached here it will spirt out with great force.

If the pus is more deeply seated in the cerebral substance, the dura mater will appear perfectly healthy and will pulsate as usual. In such a case Dupuytren plunged a bistoury into the substance of the brain and thus luckily relieved the patient from an abscess in this situation. This was doubtless a somewhat rash thing to do without previously ascertaining the presence of pus by milder means.

It is now well known that no harm results from careful puncture of the brain substance with a grooved needle or with the smaller needles of the aspirator. In these cases, therefore, a careful search should be made for the pus by means of a grooved needle or an aspirator. If the latter instrument be used only a partial vacuum should be produced, otherwise the soft cerebral substance will be forced into the needle and choke it. Care must be taken, however, that the needle is pushed straight onwards in the direction intended, all lateral movements being avoided, and in this way several punctures in different parts may safely be made. Hulke in this way detected the presence of an abscess in the frontal lobe of the brain in a boy aged 15, seven weeks after he had received a blow on the forehead causing a small stellate fracture of the outer table of the skull which was not discovered at the time of the accident. The abscess, which was situated about one inch below the surface of the brain, was opened by a knife passed along the aspirator needle and about ℥iij of thin greenish pus were evacuated. The boy recovered, but unfortunately became completely blind from atrophy of both optic papillæ following on neuro-retinitis. Hulke was led to infer the presence of an abscess in this case chiefly by the fact of hemiplegia supervening gradually many weeks after an injury to the head, a symptom to which he attaches much importance.

In some cases the presence of localizing symptoms may indicate the position in which the trephine should be applied. The indications thus afforded must be taken as a more trustworthy guide than the position of the injury. Thus in Macewen's case already mentioned the scalp wound was over the left eyebrow, but the abscess was evacuated *post mortem* by trephining over

the base of the third frontal convolution. If the abscess be deeply seated, a small drainage tube must be inserted into the cavity, otherwise the swollen brain substance will prevent drainage. Macewen uses a decalcified chicken bone tube, but in the treatment of an acute abscess he usually dispenses with the drainage tube altogether, the cavity being rapidly obliterated by the brain bulging into it.

The difficulties in the diagnosis and treatment of these cases are, however, often very great, as the following cases will show. A man was admitted into University College Hospital with an extensive lacerated wound of the scalp, denuding the pericranium. He continued free from all cerebral disturbance until the tenth day after the accident, when he complained of headache, and had a quick pulse and a hot skin; at this time it was observed that the pericranium had separated from the skull. Active antiphlogistic treatment was followed by subsidence of symptoms, and the patient went on favourably until the thirty-fourth day, when he suddenly became delirious and then unconscious, though easily roused when spoken to loudly, and then answering rationally; his pulse fell to 48. He died on the thirty-ninth day, comatose. On examination after death, the pericranium was found detached at the seat of injury; under this the dura mater was thick, yellow, and opaque, but no pus was observable. On separating the hemispheres, however, a large abscess was found situated deeply in the anterior lobe on the injured side, and protruding into the median fissure. It contained about one ounce of pus.

Another case admitted into the Hospital was that of a man who had received a large lacerated wound on the left side of the scalp in consequence of a fall. There was no injury to the bone, and the patient went on perfectly well until the seventy-seventh day, the wound having cicatrized. He was then suddenly seized with hemiplegia of the right side, from which he recovered partially on being bled; some twitching of the muscles, however, continued. On the ninety-ninth day after the accident he became comatose, and was trephined by S. Cooper, but without relief, dying with symptoms of compression of the brain on the third day after the operation. On examination thick yellow lymph was found, covering the whole of the upper surface of both hemispheres, lying between the arachnoid and pia mater, and extending into the sulci between the convolutions. There was an abscess in the substance of the brain near the surface of the right hemisphere—the side opposite to the seat of injury. Here also, though the symptoms were well marked, and the diagnosis as to the existence of pus correct, trephining was useless, as the pus could not be evacuated. These cases serve to indicate the difficulties that surround any operation undertaken with the view of evacuating matter from within the cranium.

Hernia or Fungus Cerebri.—In those cases in which a laceration of the brain and dura mater communicates with a fracture of the skull, it is occasionally found, more particularly in children, that a dark brown or bloody fungus-looking mass of cerebral matter protrudes from the wound. The period after the receipt of an injury at which this protrusion takes place, varies from a few days—eight or ten—to several weeks. It was remarked by Guthrie, and the observation has been fully confirmed, that hernia cerebri is more likely to take place through small, than through large, apertures in the cranial bones.

The protrusion is usually the result of abnormal intracranial pressure, from

inflammatory swelling of the brain substance round the injured spot, or occasionally from the formation of an abscess in the hemisphere. It may, however, result from simple non-inflammatory œdema of the brain substance, and thus may occur in a perfectly aseptic wound. As the protrusion increases in size, it becomes partially strangulated by the narrrow opening through which it passes, and its size becomes increased by œdema, and by hæmorrhage and effusion into its substance. Thus the tumour increases rather rapidly, pulsates synchronously with the brain, and may shortly attain the size of a hen's egg, or become even larger (Fig. 309.) In its composition and structure it varies. In some instances it is composed chiefly of extravasated blood; but the true fungus cerebri is composed of softened cerebral matter, often infiltrated with inflammatory exudation and blood. Softening of the brain,

Fig. 309.—Hernia Cerebri following Compound Comminuted Fracture of Right Parietal Bone.

with red discoloration, extends for some little distance under the base of the tumour. The mental condition of the patient is in many cases not much disturbed at first, there being merely some degree of cerebral irritation. Speedily, however, stupor comes on, and death in most cases eventually occurs from encephalitis, ending in coma, consequent on the inflammatory effusion that takes place within the skull.

Although the prognosis in fungus cerebri is extremely bad, it is not hopeless. In the American war seven cases of recovery are recorded. In the Italian war of 1859, Demme saw five recoveries out of twenty-one cases.

Treatment.—Preventive treatment is of the greatest importance, for if the complication be once established, its cure is very uncertain. The rigid antiseptic treatment of the wound by some efficient method is the most important preventive means at our command, for the condition is favoured by inflammatory swelling of the brain substance. Should the fungus form,

the treatment is extremely unsatisfactory. If the tumour be shaved off, as is usually recommended, it generally sprouts again, although in some fortunate cases this treatment is satisfactory. All that can be done is to slice off the growth on a level with the brain, and to apply firm pressure to the part. This may be done by means of a pad of antiseptic gauze, or a flat disc of lead or decalcified bone may be slipped beneath the edges of the opening in the skull.

SECONDARY OR REMOTE EFFECTS OF HEAD INJURIES.

Effects of Cerebral Injury on the Mental Powers.—The mental condition of patients who are recovering or who are supposed to have recovered from head injury, is one that deserves attentive consideration. It will frequently be found that the mental powers are weakened, either generally or in one special direction.

The memory will often be found to be weakened in a very remarkable manner on the recovery of the patient from the unconsciousness resulting from severe concussion. Not only is the mind a complete blank as to all that occurred during the period of the unconsciousness, but the memory may be lost for those events which immediately preceded it. Thus a driver will remember his horses taking fright; but he will never be able to recall to his recollection the various events that occurred before he was thrown from his box, and received that blow on the head which produced concussion of the brain and rendered him unconscious—events which had certainly produced impressions upon the brain before it was injured, impressions which were permanently obliterated by the concussion of the cerebral substance. The chain of memory is broken abruptly at some occurrence—often of a very trivial character—antecedent to the accident, and the gap then left can never be filled by any subsequent effort on the part of the patient.

The memory may be impaired in other ways, as for words, persons, or dates. The mind cannot grasp a subject or pursue a continuous train of thought, and is incapable of fixed attention or reasoning. Delusions of various kinds may occur, especially in connection with the mode of occurrence of the accident. I have known a patient give the most consistent and detailed accounts of the mode in which his head was injured, varying them from day to day—every one being false, but believed in by the patient at the time. The patient could be led, by a process of questioning and suggestions combined, to give almost any version that the interrogator desired; and this with great circumstantiality of detail. This is a matter of great interest and importance in a medico-legal aspect, as it is evident that an individual who has received a severe injury of the head might, in perfect good faith, give an entirely false account of the mode of infliction of the injury, by which an innocent person might be seriously compromised.

Epilepsy is not an uncommon consequence of injury of the head, especially when the blow has been inflicted in the region of the cortical motor centres. The form of epilepsy thus produced is that known as "focal" or "Jacksonian," Hughlings Jackson having maintained twenty years ago that it resulted from some organic lesion in the cortex. The attack is characterized by the definite spread of the convulsions, the spasm beginning in the part in con-

nection with the affected centre. The fit is frequently preceded by peculiar sensations in the part first affected by the spasm, and is often followed by transient paresis of the parts which are the seat of the convulsions. There is usually no loss of consciousness. It is obviously only in cases of epilepsy believed to be of the focal variety that any benefit can be expected from operative interference. The Surgeon must if possible observe for himself the exact character of the attacks, and must bear in mind that ordinary epilepsy and hystero-epilepsy may manifest themselves for the first time after an injury to the head.

Traumatic epilepsy has been said to arise from the following causes:—1st, from a neuralgic cicatrix on the scalp—the starting point of reflex convulsions; 2nd, from chronic osteitis of the part of the skull struck giving rise to thickening and induration in the bone; 3rd, from depression of bone, fracture of the inner table or the formation of osseous stalactites pressing on the surface of the brain in the motor area; 4th, from chronic thickening of the dura mater; 5th, from cystic collections of fluid in the membranes; and 6th, from scars or other lesions in the area of the cortical motor centres.

The cysts which have in many cases been found in the membranes, usually beneath the arachnoid, probably owe their origin to hæmorrhages produced by the injury, and the same explanation must be given of the cysts which have more than once been opened in the brain substance itself. In some cases no pathological appearances could be detected at the time of the operation, although it is remarkable that in some of these relief followed.

In the **Treatment** of traumatic epilepsy operative interference may be resorted to after the ordinary constitutional means have failed. If it seems to be due merely to a painful cicatrix in the scalp, we may follow Bryant's advice and dissect it up without removing any of the subjacent bone.

The practice of trephining in these cases is a very ancient one. The older Surgeons often employed it, and Cline cured a patient whose epilepsy was found to be occasioned by an osseous projection from the inner table, and whose last fit was on the operating table before the elevation of the disc of affected bone. The practice fell into disuse until revived by Lucas-Championnière, West, and others. Operative interference for epilepsy was formerly limited to removing a portion of bone in the scar of a previous injury, the Surgeon hesitating to perform any operation on the brain itself.

At the present day, however, if the Surgeon find no cause of irritation in the bone itself, he may proceed to open the dura mater with strict antiseptic precautions. The bulging of the dura and its imperfect pulsation may already have indicated the presence of a collection of clear fluid beneath it which may be evacuated.

It has been mentioned above that the epilepsy may be the result of scarring of the cortical brain substance. Under these conditions the prospects of a cure are not so good, but in the hands of Victor Horsley and others success has followed the removal of the scar with the brain substance around it. The details of the operation are the same as in removal of tumours of the brain, and will be described with the operation of trephining. In one of Horsley's first cases of this kind, the patient, a man of 22, had an old depressed fracture of the skull, giving rise to fits beginning in the right leg. During the thirteen days previous to the operation he had 2,870 fits. On exposing the brain, a scar involving the hinder end of the superior frontal sulcus and the membranes

covering it was found and removed with the brain substance around it. The patient recovered rapidly, and has had no fits since.

In some cases in which the brain presented nothing obviously abnormal that portion of the cortex has been excised stimulation of which with a weak faradic current has produced movements of the part in which the fits commenced.

Recurrence of the epilepsy after operation is in some instances no doubt due to the cicatrix which is again produced, but from the conditions present the scarring is likely to be much less marked than that following the injury itself. Putting together the statistics of Laurient, Agnew and Starr, we find a record of 201 cases of epilepsy treated by trephining, the large majority being evidently traumatic. Of these 71 are said to have been cured, 63 improved, 41 not improved, 2 were worse after operation, and 14 died. In the remainder the result was doubtful.

The operation thus holds out a chance of relief or cure in otherwise hopeless cases, but it should of course not be undertaken unless other means have failed, and the symptoms are so severe as to make the patient willing to run the inevitable dangers of the operation, and possibly to be permanently paralysed in a portion of his body. In such a case as that described on p. 757, in which the fits occur at long intervals, and the health between them is perfect, the patient had better be content to bear the ills he has.

OPERATION OF TREPHINING.

Before concluding the subject of injuries of the head, it is necessary to say a few words on the operation of **Trephining**, which may be required for one of the following conditions, viz. :—

1. Simple depressed fracture of the skull with symptoms of compression.
2. Simple depressed fracture of the skull in an adult without symptoms of compression, but in which the depression is deep and limited in area, and especially if situated over the motor region.
3. Compound depressed fracture of the skull, with or without symptoms of compression.
4. Punctured or incised fracture of the skull.
5. Extravasation of blood between the skull and dura mater from rupture of the middle meningeal artery.
6. Intrameningeal or cerebral extravasation of blood: (*a*) if definite localizing symptoms be associated with the general symptoms of compression; (*b*) if the spread of the localized paralysis or convulsions suggest continuing hæmorrhage; and (*c*) if the localized paralysis or convulsions remain unchanged after many days.
7. Intracranial abscess and septic thrombosis of lateral sinus.
8. For the removal of a bullet lodged within the cranium.
9. Traumatic epilepsy.
10. Tumours of the brain: (*a*) for the removal of the growth; (*b*) for the relief of pressure symptoms.

The use of the trephine may also be required in the removal of tumours of the skull, and it has been employed in the operation of craniectomy in microcephalic idiots, and for the drainage of the ventricular cavities in chronic meningitis and hydrocephalus.

The instruments required in the operation of trephining are a scalpel and periosteal elevator, the trephine and elevator, Hey's saw, a chisel and mallet, bone-forceps, a strong pair of dissecting forceps, and several pairs of forci-pressure forceps. In operations involving an extensive removal of bone, a circular saw, driven by an electro-motor, may prove of service.

As a preliminary step the head must be completely shaved and cleaned in the way described on p. 719. If the operation is not one of emergency the scalp should be covered with lint soaked in carbolic lotion (1 in 20), over which must be placed a layer of oiled silk. This must be applied for 12 hours before the operation and changed about every hour.

If the patient is sensible an anæsthetic must be administered. If the operation is being undertaken for the removal of a portion of the brain or a tumour, Victor Horsley, who has so highly distinguished himself in this branch of surgery, advises the use of chloroform, and that a hypodermic injection of a quarter of a grain of morphia should be previously given, as this not only makes it possible to produce the desired effect with a smaller

Fig. 310.—Trephine.

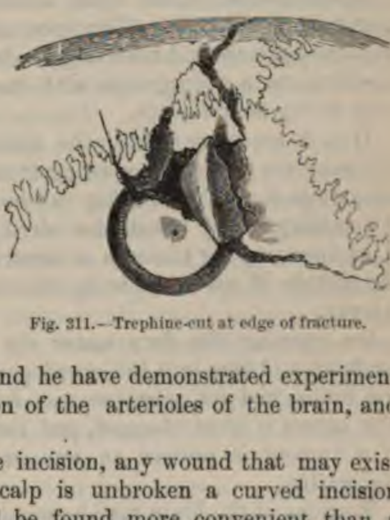

Fig. 311.—Trephine-cut at edge of fracture.

amount of the anæsthetic, but Schäfer and he have demonstrated experimentally that it tends to cause a contraction of the arterioles of the brain, and thus to diminish hæmorrhage.

The bone should be exposed by a free incision, any wound that may exist at the time being utilized. If the scalp is unbroken a curved incision exposing the bone by a single flap will be found more convenient than a T-shaped or crucial incision such as is often recommended. The periosteum must be raised in the flap with the periosteal elevator.

The bone being exposed it may not be necessary to apply any saw in some cases of depressed fractures. In others a cut may be made with a Hey's saw between two branches of a fracture. In cases in which the bone is not broken the trephine must be used. This should have a well-tempered crown, serrated half-way up its exterior ; the teeth should be short and broad ; the centre-pin must not project more than about one-sixteenth of an inch, and care must be taken that the screw which fixes it is in good working order. The centre-pin may advantageously be fixed to a solid plug which can be removed when necessary, and the trouble of the screw avoided (Fig. 310). The trephine

covering it was found and removed with the brain substance around it. The patient recovered rapidly, and has had no fits since.

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with the pin protruded, is now to be firmly applied until its teeth touch the skull; it is then worked with rather a sharp, light and quick movement, the pressure being exercised as the hand is carried from left to right. The centre-pin must be withdrawn or removed as soon as a good groove is formed by the crown, lest it perforate the skull first and injure the dura mater. In this way the outer table of the skull is quickly divided, and the diploë cut into (Fig. 311); the detritus which now rises by the crown of the trephine is soft and bloody, instead of being dry, as it is whilst the outer table is being sawn. The teeth of the trephine must be frequently freed from sawdust with a sponge. As the instrument approaches the dura mater, the sawing must be conducted more warily, and must every now and then be interrupted in order that the Surgeon may examine, with the flat end of a probe, the depth that has been reached, care being taken that this is uniform throughout the circle. The Surgeon now makes each turn very lightly, and now and then tries with a slight to-and-fro movement whether the circle of bone is loose. As soon as it is, he withdraws it in the crown of the trephine, or raises the bone by means of the elevator.

The trephine used should always be one inch or more in diameter, except in those cases in which it is only required to remove a small piece of bone to insert the elevator under a depressed fragment.

In operations on the brain substance a single trephine-aperture is not nearly large enough. The opening may be enlarged by making another trephine-aperture and removing the bone between the two with a chisel, or by marking out a deep groove with the Hey's saw and cutting the bone away with strong bone-forceps.

If it is necessary to open the dura mater this is best done by an incision following the line of the opening in the bone, but about one-eighth of an inch away from it, so that the flap can be replaced and retained by catgut sutures if necessary. Any vessels that bleed must be tied with fine catgut.

In operating for tumours or cicatrices the dura mater may be adherent to the portion of the brain to be removed, and it may then be necessary to cut it away.

On opening the dura mater the brain must be examined. A marked tendency to bulge into the opening is observed in abscess and in tumour of the brain, and its pulsation may be feeble or indistinct, or even wanting. The colour is often changed, and the membranes abnormally adherent to it. If a tumour is present an unnatural sense of resistance may be readily perceptible.

Portions of the brain may be removed by means of a common scalpel; or a blunt knife, like a tenotome in form, made of soft iron which can be bent to any form, will be found a very useful instrument. The bleeding is at first very free, but soon ceases on gentle pressure with a sponge. When the operation is complete, if the nature of the case admits of it, after the dura mater has been laid down, the bone which has been removed may be cut into small pieces, as recommended by Macewen, and planted about on the surface, where it will often adhere and help to close the opening with new bone. The flap of the scalp should then be laid down and very accurately adjusted with sutures. Drainage may be provided for by means of a small tube, but Horsley states that if one inch of the wound be left open at the most dependent part, no tube will be required, and primary union of the whole

wound, which is of the greatest importance, is favoured by this mode of treatment. Some thoroughly efficient antiseptic dressing must then be applied. The carbolic gauze, besides being very safe, has the advantage that cold can be applied over it, which cannot be efficiently done over cotton-wool dressings.

If the Surgeon is called upon to trephine with no antiseptic materials at hand, as may happen in military surgery, he should avoid the use of water; he may wipe away the blood with dry lint, and apply a dry dressing afterwards. By this means he will give the patient the best chance of escaping putrefaction of the discharges and septic meningitis in those cases in which the dura mater is wounded.

There are certain parts of the skull—over the venous sinuses, for instance, and near the base—to which no Surgeon would apply the instrument if it could possibly be avoided. If it were ever thought necessary to trephine at the frontal sinuses, the outer table must first be removed with a large crown, and the inner table sawn out with a smaller one.

The escape of cerebro-spinal fluid through a trephine aperture is a remarkable occurrence. In one such case recorded by Clement Lucas, the cerebro-spinal fluid began to escape the day after the operation. The patient, however, so far recovered as to be on the point of leaving the Hospital, when erysipelas set in, and he died of acute meningitis. After death, the track of damaged brain was found leading to the ventricle from which the fluid had escaped through the scalp. This case confirms the statement made by Clement Lucas, that when cerebro-spinal fluid escapes through the calvaria, the ventricular cavity of the brain has always been opened.

Death after the operation of trephining, when it occurs, is commonly the result of the condition for the relief of which the operation was undertaken, or of septic meningitis. As the Surgeons of former days never published statistics, we have nothing to show us the mortality that followed trephining in their times, when it was undertaken very recklessly, as we should now think; but it seems improbable that an operation so lightly undertaken could have been very fatal. The good results would appear to have been due to two causes—first, a large number of the cases in which it was done were uncomplicated by serious injury or disease of the brain; and secondly, the drainage after the operation must have been very perfect, as the piece of scalp corresponding to the bone removed was also taken away, the wound being left to heal by granulation.

In this century, before the introduction of antiseptic treatment, the death rate was very high. Of 17 cases in which the trephine proper was used at University College Hospital, by Cooper, Liston, and myself, 6 patients recovered, 1 other died of injury of the spine unconnected with the operation, and the remaining 10 died from various causes. In the late American Civil War, the results were more satisfactory than the previous experience of Army Surgeons would have led us to hope. Of 107 cases of trephining, 47 recovered; and of 114 cases where fragments of bones were removed by the forceps and elevator, without the use of the trephine, 53 recovered.

The introduction of antiseptic surgery has greatly reduced the mortality, especially in cases in which the dura mater is wounded. Kramer gives the following results obtained from published cases and the reports of hospitals in which the antiseptic system has been adopted. Of 25 cases in which primary

trephining was performed for compound fracture, 21 healed by first intention, 2 after suppuration, and 2 died, 1 of circumscribed meningitis, and 1 of meningo-encephalitis. In 6 cases of secondary trephining, 3 healed by first intention, 2 by second intention, and 1 died with hernia cerebri. In 22 cases in which the skull was opened, through a previously sound scalp, for tumours, epilepsy, old depressed fractures, &c., 21 healed without fever, 13 by first intention, and none died.

CHAPTER XXV.

INJURIES OF THE SPINE.

In no class of injuries will the diagnostic skill and powers of observation of the practical Surgeon be more severely tested than in the investigation of a case of injury to the spine. When we consider the mode of construction of the vertebral column with its complicated articulations and its intricate arrangement of muscles, tendons and ligaments, we can only wonder that it is not more frequently injured in the ordinary movements of every-day life. And when again we consider the delicate structure of the spinal cord and of the other parts contained within the spinal canal, it is truly remarkable to what severe external forces they are frequently exposed without suffering even temporary interference with their functions.

Injuries of the spine and spinal cord occur not unfrequently in the ordinary accidents of civil life—in blows, falls, horse and carriage accidents, injuries in gymnasiums, etc.—whilst the shock of a railway accident may produce injuries of great severity and in some respects differing from those resulting from other causes.

In a railway accident several conditions are often present which tend to modify and impart a special character to the results produced. Thus we must ever bear in mind the important fact, that the symptoms presented by an individual who has met with an injury under such circumstances are often largely determined by the severe fright and nervous shock to which he has been exposed—symptoms which often cannot be explained by any direct effect of the injury upon the spinal cord. But, again, the exact nature of the disturbance produced by a railway collision is often peculiar. A thrill or jar,—the *ébranlement* of French writers—is transmitted through everything subjected to it. The carriage in which the patient is seated is perhaps shattered into fragments, and by the same force the patient's body is thrown violently backwards and forwards, and a sharp vibration like an electric shock passes through every part of it. Can we then marvel that after such a violent commotion strange nervous symptoms should often manifest themselves and that the victim may, as we often hear, "never be the same man again?" The wonderful influence of the mind over the body is rarely more clearly seen than after railway accidents; the man is often so firmly convinced that he has been seriously injured, that symptoms of small moment are magnified into most serious proportions, and to this inherent dread of impending paralysis must often be added the mental anxiety necessarily associated with legal proceedings for compensation. As the result of one or more of the above causes the symptoms produced by spinal injuries resulting from railway accidents are often invested with somewhat peculiar characters; but the Surgeon must remember that in their essential nature they differ in no important respect from those due to similar injuries produced in other ways.

Cases of spinal injury divide themselves practically into two great classes: first, those in which there is obvious severe damage to the spinal column, as fracture or dislocation, associated in the large majority of cases with injury to the spinal cord and its branches by bruising or laceration; and secondly, those in which the signs of severe damage to the vertebral column are altogether absent, but in which, nevertheless, there may be unmistakable evidence of nervous derangement, the true nature of which it is often most difficult to determine.

In the consideration of this latter group of cases, the Surgeon must be reminded that the symptoms presented by the patient may be most diverse in character, and he will be called upon to decide between those due merely to slight damage to the spinal column and those resulting from injury to the nervous structures within it or to some general functional disturbance of the whole nervous system.

Our greatly increased knowledge of the physiology and pathology of the nervous system resulting from clinical experience and experimental research, and above all the study of the so-called "functional" diseases by Charcot and others, have enabled the Surgeon to distinguish between many conditions of nervous disorder resulting from injury which were formerly grouped together in one common category.

For convenience of description those cases of spinal injury which are not accompanied by the signs of fracture or dislocation will be considered under the following headings :—1. Concussion of the Spinal Cord; 2. Sprain of the Spinal Column; 3. Intraspinal Hæmorrhage; 4. Meningitis and Myelitis; 5. General Nervous Shock or Traumatic Neurasthenia; 6. Traumatic Hysteria.

Concussion of the Spinal Cord.—By this term must be understood that temporary interference with the functions of the spinal cord which may result from a more or less severe jarring or shaking of the spinal column. The condition is strictly analogous to that which we find in concussion of the brain, and in both the temporary character of the symptoms is good evidence that the nerve tissue has suffered no gross damage. In the more severe cases at least it is probable that capillary hæmorrhages occur in the substance of the cord, and as in the case of the brain, no sharp line of demarcation can be drawn between such a condition and those more serious coarse lesions of bruising and laceration. Cases of this variety are undoubtedly rare, but there is little doubt that simple uncomplicated concussion may result from falls, blows upon the spine, and from the severe shaking of the spine which occurs in railway collisions.

The *Symptoms* must necessarily vary according to the part of the cord which is affected, but, speaking generally, they are usually seen as transient motor disturbances in the limbs, less commonly with slight interference with the conduction of sensory impressions, and sometimes temporary paresis of the sphincters. Byrom Bramwell has recently drawn special attention to the occurrence of these symptoms amongst miners, as the result of the fall of heavy masses of coal and "roof" upon the back. Under such circumstances temporary paralysis of the bladder, necessitating the use of the catheter, is not uncommon, and this symptom may be accompanied by temporary numbness and loss of power in the legs. These symptoms usually pass off in a few days, and, according to those who have large experience in mining districts, subsequent symptoms indicative of organic disease of the spinal cord rarely, if ever, follow. Concussion of the brain and concussion of the spinal cord

are thus seen further to resemble each other in the complete and rapid recovery which in the large majority of cases follows; should this result not ensue, the Surgeon must look for some other cause for the persistence of the symptoms.

Sprain of the Spinal Column.—A large number of cases of spinal injury are included under the general term "sprain;" and, as we shall see, the symptoms produced are often so marked that the Surgeon may easily be misled into the belief that the spinal cord itself has been damaged. The actual injury produced undoubtedly varies greatly in different cases; in the slighter forms of sprain, muscles and ligaments are more or less damaged by the sudden stretching to which they are subjected; whilst in the more severe forms these structures are torn in varying degrees, and at times it is probable that the vertebræ may be wrenched apart without remaining permanently displaced. Synovitis of one or more of the articulations of the vertebræ has also been suggested as a likely occurrence. Not less varied than the actual results produced are the causes which may occasion a sprain of the spine; blows, falls on the back, wrenches and twists of the part, or even the lifting of a heavy weight may be mentioned as likely causes of this injury.

In an uncomplicated sprain the spinal column itself or the structures attached to it alone suffer, but it will easily be understood that in the more severe cases the symptoms thus produced will be complicated by others which indicate that the spinal cord or the nerve-roots have been damaged by bruising and hæmorrhage.

The *Symptoms* of a sprain of the back are usually sufficiently obvious and profoundly impress the patient, who is naturally apt to estimate the severity of the injury which he has suffered by the amount of pain which he feels. Localized pain in the spine is, in fact, the most prominent symptom; it may immediately follow the injury, or may be first felt some hours afterwards. The pain is often accompanied by marked local tenderness on firm pressure, and in some cases by superficial bruising. The slightest movement intensifies the suffering, and stiffness of the spine is the result. In addition to the definite localized pain which is the direct result of the sprain, widespread cutaneous hyperæsthesia over a large part of the back may supervene, and the Surgeon must be careful not to confuse this with referred pains due to irritation of the nerve-roots. Herbert Page, who has paid special attention to this class of spinal injuries, has shown how such cases may not unfrequently be associated with a condition of "pseudo-paralysis." The pain may be so severe, especially in sprains of the lumbar region, that the patient dreads to perform even the slightest movement of the lower limbs; and, for the same reason, he avoids those straining efforts which are essential for the acts of micturition and defæcation, and thus actual retention of urine and obstinate constipation may be the results. The patient will very naturally imagine that he is the subject of true paralysis, and the Surgeon must beware lest he fall into the same error. In considering the important question of treatment it will be seen how essential it is that the true nature of this pseudo-palsy be thoroughly recognized, and that exercise, and not prolonged rest in bed, be enforced as the best means of producing a cure.

Intraspinal hæmorrhage.—It will be seen in the subsequent consideration of fractures of the spine that the effusion of blood within the spinal canal plays an important part in the production of the symptoms. The cases now under consideration are those in which a similar intraspinal hæmorrhage

occurs independently of severe damage to the spinal column. Hæmorrhage within the spinal canal may occur: (a) between the vertebræ and the dura mater; (b) into the membranes; (c) into the substance of the spinal cord. In these respects intraspinal extravasations closely resemble those which occur as the result of injury within the cranium. In the more severe forms of sprain of the spine it is probable that hæmorrhage between the bones and the dura mater is not an unfrequent occurrence, especially where partial separation of vertebræ has occurred with laceration of the intervertebral substance. This, no doubt, in some cases accounts for the symptoms indicating slight damage to the nerve-roots, which we have already seen are occasionally met with in severe cases of sprain.

The exact way in which intraspinal hæmorrhage is produced by injury without serious damage to the spinal column is somewhat doubtful. According to one view the cord is bruised by the severe shaking within the canal to which it has been subjected; whilst others would explain the hæmorrhage by supposing that the cord is acutely bent at the time of the injury by the "partial dislocation with recoil" which occurs. Thorburn points out that the definitely localized characters of many hæmorrhages into the spinal cord favours the latter view, as well as the fact that in cases of extravasation into the cervical portion of the cord, the favourite seat is that part which corresponds to the fourth, fifth, and sixth cervical vertebræ where the curve is most pronounced. Effusions of blood into the membranes may be more or less widely diffused, whilst an effusion into the substance of the cord—"hæmatomyelia"—usually occurs as a single focus. This is much more common in the cervical than in either of the other regions, and the central grey matter suffers more severely than the more superficial white substance.

In the slighter forms of intraspinal hæmorrhage, especially of the meningeal variety, the effused blood is slowly absorbed and the symptoms correspondingly disappear. In the more severe cases, however, especially if the hæmorrhage be in the substance of the nervous tissue, permanent damage of varying degree results and manifests itself by a corresponding persistence of the symptoms. A gradual extension of the symptoms due directly to the hæmorrhage indicates the occurrence of a myelitis spreading from the affected area.

The *Symptoms* must necessarily vary according to the part of the spinal cord which is affected and the extent to which it is damaged by the effusion of blood. In many cases the symptoms will be found immediately after the accident, although, as in the case of intracranial hæmorrhage, they will often not reach their maximum for a variable period, that is to say, not until the bleeding finally ceases. In other cases, especially of the meningeal variety, an interval will elapse before the quantity of effused blood is sufficient to cause any recognizable disturbance of function; whilst the evidence that hæmorrhage has occurred may first declare itself after the temporary symptoms due to concussion have passed away.

The symptoms of *meningeal hæmorrhage*, as pointed out by Gowers, bear some resemblance to those of meningitis. Pain in the back is common, with paroxysmal pains referred along the course of the nerves, which take origin in the affected area. Spasmodic contraction of the muscles supplied by the nerve-roots which arise at the seat of the extravasation takes place, and is followed by paresis. If the hæmorrhage be extensive there may also be weakness and lessened sensitiveness in the limbs below the lesion. Meningeal hæmorrhage

in the cervical region causes pain in the neck and arms, and according to Gowers, "dysphagia, interference with respiration, and dilatation of the pupils may be added to the other paralytic symptoms;" in the dorsal region a girdle pain may encircle the chest or abdomen; in the lumbar region there will be pain and paralysis of the lower limbs, affection of the sphincters, and diminution of the tendon-reflexes. In more than one recorded case of meningeal hæmorrhage symptoms of ascending paralysis have resulted from the accumulation of blood in the spinal canal around the cord.

The symptoms of *hæmorrhage into the spinal cord* are well marked from the first. The paralysis is usually not preceded by those irritation symptoms which so often occur as the result of meningeal hæmorrhage. If the lesion be extensive the effects may be the same as those which will subsequently be seen to follow complete or partial transverse lesions of the cord. Cases occur, however, in which, as the result of localized hæmorrhage into the grey matter, the conducting power of the cord is but little interfered with, but in which, if the cervical or lumbar enlargement be affected, varying forms of paralysis and loss of sensation may result.

In the case of the cervical enlargement much has been done to indicate the mode of representation of the muscles of the upper limbs in the cord. The root origin of the muscular nerves has been investigated experimentally in monkeys by Ferrier and Yeo; by the method of dissection by Herringham; and clinically by Gowers, Thorburn and others. Thorburn especially has studied the subject in connexion with hæmorrhage into the substance of the cervical enlargement of the cord as the result of injury. He is thus led to arrange the muscles of the upper limb in the following order according to their root supply:—

Supraspinatus and infraspinatus. Teres minor (?).	4th cervical nerve.
Biceps. Brachialis anticus. Deltoid. Supinator longus. Supinator brevis (?).	5th cervical nerve.
Subscapularis. Pronators. Teres Major. Latissimus dorsi. Pectoralis major. Triceps. Serratus magnus.	6th cervical nerve.
Extensors of the wrist.	7th cervical nerve.
Flexors of the wrist.	8th cervical nerve.
Interossei. Other intrinsic muscles of the hand.	1st dorsal nerve.

This table must be looked upon as merely indicating the general plan of arrangement and not the details of the nerve supply of each muscle, which in every case probably is related to more than one nerve-root. The arrangement

of the centres for the different muscles in the grey matter of the anterior cornua may also be looked upon as probably agreeing with that above given. The important bearing of these considerations upon the diagnosis of the position and extent of a hæmorrhage into the cervical region of the spinal cord is obvious, and is exemplified by many of the cases recorded by Thorburn. If the centre for any particular muscle be actually destroyed by the hæmorrhage, that muscle will be permanently paralysed, will undergo atrophy, and exhibit the electrical reaction of degeneration. If the damage be slighter complete recovery may take place. In some cases the muscles supplied from the most damaged area are paralysed, whilst those supplied from higher and lower levels may be affected by irritative spasm ; as in a case recorded by Thorburn in which the triceps and latissimus were paralysed, whilst the biceps and subscapularis (supplied above the lesion) and the flexors of the hand and fingers (supplied below the lesion) were spasmodically contracted.

Ross has shewn that the sensory nerves supplying the upper limb, coming from the fifth cervical to the first dorsal nerve inclusive, supply the limb in numerical order from the radial to the ulnar side. Hence, as Thorburn points out, the higher the damage extends in the cord the further will the anæsthesia extend from the ulnar towards the radial side of the limb. In a case of fracture of the dorsal spine, recently in University College Hospital, the first evidences of the invasion of the cervical enlargement by the ascending myelitis were paresis of the intrinsic muscles of the hand and impairment of sensation along its ulnar border.

The remarks above made concerning the effects of hæmorrhage into the cervical part of the cord can be more or less applied to those cases in which the lumbar enlargement is the seat of the lesion.

These cases are, however, much rarer, and the arrangement of the lumbar and sacral roots at their origin renders them less liable than the cervical roots to separate damage. The exact relations of a small hæmorrhage may, however, be in some cases determined by reference to the following table, founded upon cases collected by Thorburn :—

Sartorius. Adductors of thigh. Flexors of thigh.	Third lumbar nerve.
Extensors of knee. Abductors of thigh.	Fourth lumbar nerve.
Hamstring muscles.	Fifth lumbar nerve.
Calf muscles. Glutei. Peronei. Extensors of ankle. Intrinsic muscles of foot.	First and second sacral nerves.
Perineal muscles.	Third sacral nerve.
Bladder and rectum	Fourth sacral nerve.

The relation of the sensory distribution of the nerve-roots from the last dorsal to the coccygeal may be enumerated from above down as follows: Upper part of buttock, groin and scrotum, outer side, front and inner side of

, front and inner side of leg, lower part of buttock, back of thigh, leg foot, perinæum and anus, and lastly, skin from coccyx to anus. By ully noting the distribution of the anæsthesia and the muscular paralysis, njury may be referred to one or more nerve-roots, or to that part of the from which they take origin.

cases in which we have evidence of damage to in nerve-roots the level of the lesion in its rela- to the spines of the vertebræ may vary within in limits. The varying relations of the root ns of the nerves to the spines of the vertebræ are sented in the accompanying diagram (Fig. 312), ared by Professor R. W. Reid of Aberdeen, to n I am much indebted for permission to repro- it. The right hand column represents the ebræ, and each nerve is represented by a shaded k.

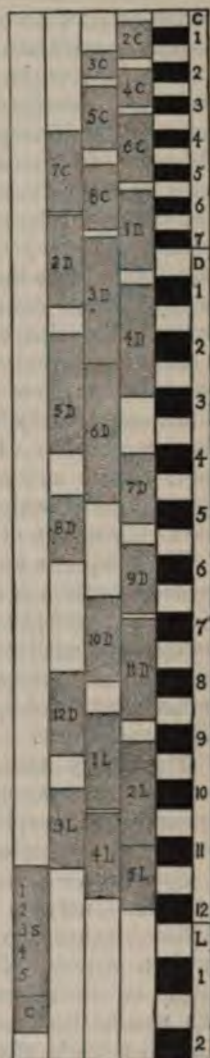

Fig. 312.—Diagram showing the varying relations of the origins of the Spinal Nerves to the Spines of the Vertebræ (Reid).

eningitis and Myelitis.—The occurrence of *cute myelitis* after an injury to the spine is very It may possibly result from the concussion to h the spinal cord has been subjected, but it seems probable that the inflammation in such cases is to capillary extravasations into the cord. The ptoms produced are much like those of hæmor- e, but the difference consists in the time of their t; amongst them may be mentioned spinal pain tingling in the limbs, paraplegia with spasm, ular paralysis of the limb muscles, girdle pain, affections of the sphincters. In the case of a who was severely shaken in a railway collision, who died paraplegic six weeks later, Gowers found cations of subacute myelitis throughout the dorsal n. Acute meningitis following obscure spinal ries is also very rare. It was, however, at one supposed that *chronic meningo-myelitis* was a mon cause of those complex symptoms which may ually develop after this class of injuries, and h will be considered below. The cerebral acters of many such symptoms were explained supposing that the chronic inflammation had ly extended from the membranes of the spinal to those of the brain. The subject is one of eme interest, but it must suffice here to say that view above expressed was founded on very scanty ological information, and that Surgeons are now rally agreed that chronic diffuse meningo-myelitis rarely results from injury. It seems, however, in that in some cases an injury to the spine is an rtant factor in the causation of some of the definite system diseases of ord; thus locomotor ataxy, following such injury, has been recorded by Barbour, and others.

General Nervous Shock. Traumatic Neurasthenia.—Two separate factors frequently act together in the production of the varied symptoms which may result from an injury to the spine: first, the physical injury itself which mechanically damages to a more or less marked degree the vertebral column or the parts contained within it; and, secondly, the severe fright which is an important element in many spinal injuries, especially such as are produced in railway accidents with all their attendant horrors.

The effects of the physical agent have already been briefly considered under the separate headings of concussion of the spinal cord, sprain of the spinal column, and intraspinal hæmorrhage. The effects of this physical injury, although often most complex, can, however, be explained on an anatomical basis and are directly related in their severity and persistence to the nature and amount of the actual damage produced. The symptoms now about to be considered belong to an entirely different category and present this remarkable feature, that they are often altogether out of proportion to the amount of bodily damage sustained and cannot be satisfactorily explained by any direct injury to the spinal cord. In Chapter VIII. it has been pointed out how large a share the psychical effect of an injury may take in the production of the shock which more or less immediately follows it, so much so indeed that death may actually be caused in this way without the occurrence of any bodily damage whatever. If this be true of immediate shock, it is no less so of those more remote and persistent symptoms which frequently follow an injury to the back, and which from their frequent occurrence after railway accidents have been spoken of collectively under the name of "railway spine."

The symptoms which are given in detail below were formerly spoken of as secondary effects of spinal concussion, but in the light of more recent observations on the subject of "functional" affections of the nervous system, it seems necessary to modify this view as to their nature and to class them together as the result of "general nervous shock" or "traumatic neurasthenia," convenient terms largely used by writers on this subject, and probably expressing accurately their true nature.

The injury itself and the fright or mental shock accompanying it have together so seriously disturbed the healthy working of the whole nervous system—cerebro-spinal and sympathetic—that months or even years may elapse before complete recovery follows.

Symptoms.—From the above remarks it will be gathered that the symptoms of general nervous shock are indicative of a condition of more or less pronounced exhaustion of the whole nervous system—the "*neurasthenia*" of modern writers. The immediate shock produced by the accident may be slight or absent, and it is not until some hours or days have elapsed that the patient becomes gradually aware that something is wrong with him. In other cases, after the first and immediate effects of the accident have passed off, there is a period of comparative ease, and of remission of the symptoms, during which the patient imagines that he will speedily regain his health and strength. This period may last for many weeks, possibly for two or three months. Although there is often this long interval between the time of the occurrence of the accident and the supervention of the more distressing symptoms, it will be found, on close inquiry, *that there has never been an interval of complete restoration to health*. The patient's friends remark that "he is not the man he was." He has lost bodily energy, mental capacity, and

business aptitude. He looks ill and worn; often becomes irritable and is easily fatigued. He still believes that he has suffered no serious or permanent hurt, and so long as he is at rest, he will feel tolerably well; but any attempt at ordinary exertion of body or mind brings back all those feelings or indications of nervous prostration and irritation characteristic of these injuries. After a lapse of several months—from three to six—the patient will find that he is slowly but steadily becoming worse, and he then, perhaps for the first time, becomes aware of the serious and deep-seated injury that his nervous system has sustained.

The *countenance* is usually pallid, sometimes even livid, and has a peculiarly careworn, expressionless look—the patient generally looking much older than he really is, or than he did before the accident. I have, however, seen instances of flushing of the face, apparently due to disturbance of the vaso-motor action of the sympathetic.

The *thoughts* are confused. The patient cannot concentrate his ideas so as to pursue a connected line of reasoning; he attempts to read, but is obliged to lay aside the book or paper after a few minutes. All *business aptitude* is lost; partly from impairment of memory, partly from confusion of thought and inability to concentrate ideas for a sufficient length of time. The *temper* is often changed for the worse, the patient being fretful, irritable, and in some way—difficult perhaps to define, but easily appreciated by those around him—altered in character.

The *sleep* is disturbed, restless and broken. The patient wakes up in sudden alarm; he dreams much, and his dreams are distressing and horrible.

The *head* is usually of its natural temperature, but sometimes hot. The patient complains of various uneasy sensations in it; of pain, tension, weight, or throbbing; of giddiness; of a confused or strained feeling in it; and frequently of loud and incessant noises, described as roaring, rushing, ringing, singing, sawing, rumbling, or thundering. These noises vary in intensity at different periods of the day; but, if once they occur, they are never entirely absent, and are a source of great distress. Headache is a very common symptom; it is often occipital and is increased by the slightest mental effort.

The *organs of special sense* usually become more or less seriously affected, being sometimes oversensitive and irritable, whilst at others their functions are impaired or perverted. In many cases we find a combination of all these conditions in the same organ. Accommodative asthenopia is a common evidence of the general want of muscular tone. The ciliary muscle is unable to meet the demands made upon it for near vision, and hence reading, sewing, &c. become difficult or impossible. This form of asthenopia is especially pronounced in those who are already slightly hypermetropic or presbyopic. Photophobia is not uncommon. The pupil may be dilated and its movements sluggish. The condition of the optic disc in cases of spinal injury is separately considered on page 800.

The *hearing* may be variously affected. Not only does the patient commonly complain of the noises in the head and ears that have already been described, but the ears, like the eyes, may be oversensitive or too dull. One ear is frequently oversensitive, whilst the other is less acute than it was before the accident. Loud and sudden noises are peculiarly distressing to these patients. *Taste and smell* are sometimes, but more rarely, perverted.

The *sense of touch* is impaired. The patient cannot pick up a pin, cannot

button his dress, cannot feel the difference between different textures, as cloth and velvet. He loses the sense of *weight*, and cannot tell, for instance, whether a sovereign or a shilling is balanced on his finger. *Speech* is rarely affected.

The *general muscular power* is often much impaired, especially in the lower limbs, and thus the gait of the patient becomes altered. He walks more or less unsteadily, generally uses a stick, or, if deprived of that, is apt to lay his hand on any article of furniture that is near to him, for the purpose of steadying himself. He keeps his feet somewhat apart, so as to increase the basis of support, and consequently walks in a straddling manner. As one leg is often weaker than the other, he totters somewhat, and raises the foot but slightly off the ground, so that the heel is apt to touch. He seldom drags the toe; but, as he walks flat-footed as it were on one side, the heel drags. This peculiar straddling, tottering, unsteady gait, with the spine rigid, the head erect, and looking straight forwards, gives the patient the aspect of a man who walks blindfolded. The patient cannot generally stand equally well on either foot. One leg usually gives way immediately under him if he attempt to stand on it. He often cannot raise himself on his toes, or stand on them, without immediately tottering forwards. His power of walking is always very limited, seldom exceeding half a mile or a mile at the utmost. He cannot ride, even if much in the habit of doing so before the accident. There is usually considerable difficulty in going up and down stairs—more in going down than up. The patient is obliged to support himself by holding on to the balusters, and often brings both feet together on the same step.

The loss of motor power in the hand is best tested by the force of the patient's grasp. This may be roughly estimated by telling him to squeeze the Surgeon's fingers, first with one hand and then with the other, or more accurately by means of the dynamometer, which shows on an index the precise amount of pressure exercised in grasping. It may be added that the electrical excitability of the muscles is not lost, and that their nutrition only suffers as the result of want of exercise and the general wasting of the body.

Modification or diminution of sensation in the limbs is one of the most marked phenomena in these cases. In many instances the sensibility is a good deal augmented, especially in the earlier stages. The patient complains of shooting pains down the limbs, like stabs, darts, or electric shocks. The surface of the skin is sometimes oversensitive in places on the back; or, in various parts of the limbs, hot, burning sensations are experienced. After a time these sensations give place to various others, which are very differently described by patients. Tingling, a feeling of "pins and needles," a heavy sensation as if the limb were asleep, creeping sensations down the back and along the nerves, and formication, are all commonly complained of. These sensations are often confined to one nerve in a limb, as the ulnar or the musculo-spiral. Numbness, more or less complete, may exist independently of, or be associated with, all these various modifications of sensation. It may be confined to a part of a limb, may influence the whole of it, or may extend to several limbs. Its degree and extent are best tested by Brown-Séquard's æsthesiometer.

Coldness of one of the extremities, dependent upon loss of nervous power and defective nutrition, is often perceptible to the touch, and may be determined by the thermometer; but in many cases the sensation of coldness is far greater to the patient than it is to the Surgeon's hand, and not unfrequently no appreciable difference in the temperature of two limbs can be determined

by the most delicate clinical thermometer, although the patient experiences a very distinct and distressing sense of coldness in one limb.

The *heart* will often continue to beat in a violent or tumultuous manner for many months after the receipt of a severe nervous shock, the pulse however being feeble. This disproportion between the force of the heart's action and that of the pulse is very marked in many of these cases, and is a proof of the important part played by the sympathetic in these cases, as is further indicated by the flushings, sensations of heat and cold and excessive sweating, which are common symptoms.

The condition of the *genito-urinary organs* is seldom much deranged in the cases under consideration. Sometimes there is suppression of urine more or less complete for two or three days; retention very rarely occurs except in the cases of profound shock at the time of the accident. Page draws attention to the subsequent trouble which may result if the distension of the bladder thus produced be left long unrelieved. Some weakness in the action of the bladder and inability to empty it completely may be the result of the general impairment of muscular power.

The progressive development of the various symptoms that have just been enumerated often extends over a lengthened period. In the early stages, the chief complaint is a sensation of lassitude, weariness and inability for mental and physical exertion. These are followed by motor and vaso-motor disturbances, and affections of the special senses. With appropriate treatment complete recovery may usually be anticipated, but permanent impairment of nervous power may undoubtedly be the result in some cases. Page records two cases in which death occurred after symptoms of general nervous shock had persisted for several weeks; in both cases the brain and spinal cord presented no signs of structural disease.

Traumatic Hysteria.—In the last section it has been shown how seriously the whole central nervous system may suffer as the result of an injury to the spine, being in fact left in a state of exhaustion. Other symptoms of a functional nature may however be produced which are more local in character and usually manifest themselves as definite impairments of motion and sensation; they are by no means necessarily accompanied by the emotional and psychical phenomena which are frequently associated with hysteria. Of late years no subject in the whole range of medical science has received more attention than that relating to the phenomena and symptoms of hysteria and the neuroses generally. Amongst the many writers upon the subject must be specially mentioned the late J. M. Charcot, to whom more than any other we are indebted for a clear recognition of the true nature of hysteria. In speaking of the occurrence of hysteria in the male sex Charcot says: "One can conceive that it may be possible for a young effeminate man, after excesses, disappointments, profound emotions, to present hysterical phenomena, but that a vigorous artizan, well-built, not enervated by high culture—the stoker of an engine for example—should, after an accident to the train by a collision or running off the rails, become hysterical for the same reason as a woman, is what passes our imagination." Charcot further shows that the symptoms of hysteria in the male may manifest a permanence and obstinacy in marked contrast to the instability which so often characterizes the symptoms in the female. For the right appreciation of the class of cases now under consideration it must be assumed as definitively proved: first, that

hysterical phenomena may be the result of an injury; secondly, that such phenomena may occur in men and in individuals who have shewn no signs of the so-called "hysterical" or "neurotic" temperament; thirdly, that the emotional symptoms of hysteria may be altogether absent; and lastly, that the symptoms may be of a remarkably obstinate and permanent character.

It may here be pointed out that the reason for considering the subject of traumatic hysteria in this place, is that, not only does it frequently occur as the result of spinal injuries, but the local motor and sensory phenomena produced frequently closely imitate the paralyses and defects of sensation which result from gross lesions of the spinal cord and the nerve-roots.

It would be beyond the scope of this work to enter into a full consideration of the highly-interesting subject of Traumatic Hysteria, and the reader who wishes for further information may consult the works of Charcot, Oppenheim, Page, Thorburn and others. It will be sufficient here to indicate the chief characters of some of the more important phenomena.

Symptoms.—The condition of acute hysteria which may follow an injury to the spine, especially such as occurs in a railway accident, merely needs mention. In a chronic case the true nature of the affection is easily recognizable if it is accompanied by the emotional symptoms and "hysterical seizures" which are so common in hysteria in the female. The purely local phenomena need further consideration.

1. *Motor.*—The most common local effect is paralysis, although spasmodic contraction may occur. The paralysis may assume the monoplegic, hemiplegic or paraplegic form. It is in those cases in which one limb only is affected, or in which paraplegia exists that difficulty may arise in distinguishing it from the paralyses due to damage to the spinal cord by hæmorrhage and bruising. It is an important fact that if the paralysis of a limb be partial the muscles affected in hysteria are usually those which are associated in their action and thus the patient is unable to perform one or more particular movements; whereas we have already seen that in cases of organic lesion of the cord by hæmorrhage or later by myelitis the paralysed muscles can be grouped according to the spinal nerve-roots by which they are supplied. Charcot also insists upon the important fact that in a case of traumatic hysteria the muscles often do not atrophy and do not exhibit the reaction of degeneration.

2. *Sensory.*—Varying degrees of anæsthesia are frequently associated with hysterical paralysis. The presence of hemianæsthesia associated with any form of paralysis after a spinal injury may be taken as strong evidence that the paralysis is functional and not due to any gross lesion. In such cases the anæsthesia is usually more marked in the paralysed limb than elsewhere. Complete flaccid paralysis with anæsthesia of one limb constitutes another type of an hysterical condition. The loss of sensation is deep and superficial, and the muscular sense may be totally lost. Patches of hyperæsthesia are often present. The tendon-reflexes may be diminished.

We thus see that a careful study of the extent and character of the paralysis and anæsthesia may often lead to a recognition of their true nature. Amongst other conditions which may be present, and which will greatly assist in the diagnosis, may be mentioned :—Contraction of the field of vision for white light; diminution or loss of the sense of hearing, smell or taste; and insensibility of the pharynx.

Affections of the Eye after Spinal Injury.—In the various forms of spinal injury it has been seen that some affection of the eyes is not uncommon; it will be convenient now briefly to consider these effects in a more detailed manner. The following conditions need separate attention:—Asthenopia, Photophobia, Alterations in the Pupil, Changes in the Field of Vision, and Congestive and Inflammatory Affections of the Optic Nerve.

Asthenopia.—This occurs as a symptom of general nervous shock resulting from spinal injuries. We have already seen that it is an evidence of nervous exhaustion, and is due to failure of accommodation. The patient complains of dimness and weakness of sight, so that he cannot define the outlines of small objects; the letters of small print are often seen clearly for a few seconds, but soon they run into one another, and become obscured and blurred. If the eyes were free from errors of accommodation before the accident the asthenopia will disappear with restoration to health; but in many cases the defect is merely an exaggeration of a condition of hypermetropia or presbyopia previously existing.

Photophobia.—The condition of nervous exhaustion may be accompanied by an irritable condition of the eyes. They cannot bear a strong light, even that of an ordinary window, in the daytime, or unshaded gas or lamplight. In consequence of this irritability of the eyes, the brows become involuntarily contracted, and the patient acquires a peculiar frown so as to exclude light as much as possible. This intolerance of light may amount to perfect photophobia, and is then associated with congestion of the conjunctiva accompanied by lachrymation. One or both eyes may be thus affected. The condition is usually accompanied by muscæ volitantes and spectra, rings, stars, spots, flashes, and sparks, or an appearance of white-coloured flame. The appearance of a fixed luminous spectrum, a line, circle, or coloured bar across the field of vision, is sometimes complained of. There is an undue retention of the image in many cases; and where the patient has looked at any fixed object, such as the sun or the fire, complementary spectral colours, often of the most beautiful character, of varying degrees of intensity, will develop themselves in succession. The patient is in some cases conscious of the circulation in his own eye, which becomes distinctly visible to him, even in its pulsatory character.

Alterations in the Pupil.—A dilated pupil with sluggish movements is commonly met with in general nervous shock. In cases of damage to the cervical and upper dorsal regions of the spinal cord by hæmorrhage or laceration, or by the subsequent inflammation, contraction of the pupil has been observed. This may be unilateral or bilateral, and results from paralysis of the pupil-dilating fibres. Irritation of this part of the cord, on the other hand, as by compression, is followed by irritative dilatation of the pupil. Budge and Waller, in 1851, first demonstrated that the filaments of the sympathetic, which supply the eye, take their origin from that part of the spinal cord which is contiguous to the origin of the first pair of dorsal nerves. Hence, by these physiologists the part of the cord from which these fibres arise has been called the "*cilio-spinal region.*" The pupil-dilating fibres leave the cord by the anterior nerve-roots from the fifth cervical to the fifth thoracic, and pass to the last cervical and first thoracic ganglia of the sympathetic; thence they pass through the cervical sympathetic to the Gasserian ganglion, and reach the iris in the ciliary branches of the ophthalmic

division of the fifth nerve. The contraction of the pupil which is produced by a destructive lesion of the cilio-spinal region may be accompanied by narrowing of the palpebral fissure from paralysis of the involuntary muscular tissue which is present in both the upper and lower lids.

Changes in the Field of Vision.—Charcot has drawn especial attention to the retraction of the field of vision which is frequently present in cases of hysteria, and it has already been mentioned incidentally that the detection of this symptom by the use of the perimeter may be of assistance in distinguishing between a paralysis of hysterical origin, and one resulting from a lesion of the spinal cord. The retraction may be bilateral, but in cases of unilateral affections of sensation the change in the field of vision may exist on the affected side only. In association with this retraction of the field of vision for white light may be found a retraction of the visual fields for all colours, passing on in some cases to complete loss of colour vision. The normal relation of the fields of perception of red and blue light may be reversed, the field for red remaining larger than that for blue.

Changes in the Optic Nerve.—The changes in the ophthalmoscopic appearances of the fundus after injuries of the spine were carefully studied by Wharton Jones and Allbutt, but more recent investigations seem to shew that changes in the optic disc in this class of injuries are not so common as was formerly supposed. The subject has recently been inquired into by William Thorburn, who has studied the visible optical changes in definite organic lesions of the cord, in slight injuries of the back not implicating the cord, and lastly, in injuries complicated by severe general shock. Thorburn concludes that in severe injuries to the spinal cord below the third dorsal roots, no changes occur in the optic disc; whilst "in four cases of crush of the upper part of the spinal cord (third cervical to second dorsal) where frequent examinations were made, ophthalmoscopic changes were found in three, being absent in one only." The changes consisted of haziness, with want of definition of the disc, and slight distension of the retinal veins. In the slighter forms of spinal injury, Thorburn concludes that no changes occur in the optic disc, although the chronic myelitis or meningitis which very rarely follows, may perhaps give rise to it. Lastly, there is some evidence that vascular changes in the disc may follow injuries to the spine in which general nervous shock is produced, probably of the same nature as the vaso-motor changes which occur elsewhere in this condition. In the light of our present knowledge of the subject it must be concluded that optic neuritis after spinal injuries is a rare occurrence.

Diagnosis.—The differential diagnosis between the various conditions above described must often be a matter of the greatest difficulty, especially when it is remembered that the symptoms in any particular case may be produced by two or more of these conditions combined. The symptoms of uncomplicated concussion are immediate in their onset and transient in character; those due to hæmorrhage appear early, rapidly reach their maximum, and according to the amount of damage produced, they may gradually pass away entirely or leave permanent impairment of function. Symptoms of meningitis and myelitis come on after an interval, and are often progressive. Enough has already been said to enable the Surgeon to recognise such cases as are "functional" in character. The detection of *malingering* in the subjects of supposed spinal injury may severely test the Surgeon's

knowledge, and he must endeavour alike to avoid the serious errors of too quickly assigning base motives to a genuine sufferer or of being misled by the plausible story and clever deceit of the malingerer. *Syphilitic affections of the cord and its membranes* may be confounded with the after-effects of spinal injury, whilst the disease may itself be called into activity by the injury. The antecedent history, and perhaps the concomitant evidence of constitutional syphilis in one of its minor forms, will determine the diagnosis.

The PROGNOSIS of spinal injuries is a question of extreme interest from a medico-legal point of view and is often involved in much difficulty.

So far as life is concerned it is only in cases of severe and direct blows upon the spine, causing intraspinal hæmorrhage or actual laceration of the cord, that a speedily fatal termination is to be feared. Death may rarely occur at a later date from inflammation of the cord and its membranes, or still more rarely at a remote period from progressive development of structural changes. In considering the probability of complete recovery it may be said that this is looked for after simple concussion and in cases of spinal sprain however severe. The subsequent development of diseased conditions of the cord in these cases is extremely rare, but should they occur the prognosis will always be very unfavourable. In forming an opinion as to the patient's probable future state, it is of far less importance to look to the early severity of the symptoms than to their progressive and insidious development. In all cases in which the symptoms produced are recognized as "functional" and unconnected with structural changes in the cord or its membranes, a hopeful prognosis may be given if suitable treatment is carried out faithfully by the patient and his friends. It does undoubtedly happen that in certain cases, happily few, the general nervous shock to which a patient has been exposed in a railway accident may leave permanent traces in an alteration of the temperament and the nervous state generally.

TREATMENT.—In the **Early Stages of a case of Injury of the Spine,** the injured part must be given complete and absolute *rest*. The importance of rest cannot be over-estimated. Without it, no other treatment is of the slightest avail; and it would be as irrational to attempt to treat an injured brain or a sprained ankle without rest, as to try to benefit a patient suffering from a severe concussion or wrench of the spine unless he be kept quiet.

In order to secure rest efficiently, the patient should be made to lie prone on a couch. In the prone position, the spine is the highest part of the body; thus passive venous congestion and determination of blood, which are favoured when the patient lies on his back, are entirely prevented. Again, the absence of pressure upon the back is a great comfort when that part is unduly sensitive and tender, and is a source of additional safety to the patient, if he be paraplegic, by lessening the liability to the formation of bed-sores. Lastly, the prone position presents this advantage over the supine, that it allows the ready application of local treatment to the spine. In some instances complete and absolute rest may be secured to the injured spine by the application of a gutta-percha case to the back, embracing the shoulders, nape of the neck and back of the head; or by letting the patient wear a stiff collar, so as to give support to the neck. In these cases Sayre's plaster of Paris jacket will be found of the utmost service. It secures more perfect and continuous rest than any other apparatus.

In cases of simple concussion a period of complete rest is the only treat-

ment required. Rest is essential in the treatment of a sprain of the spine, but it is difficult to decide how long the patient should keep his bed. Page finds that this is rarely required for longer than three weeks, and the restoration of free mobility may be greatly hastened by systematic massage, and in some cases by faradisation of the spinal muscles.

If the symptoms are indicative of intraspinal hæmorrhage, prolonged rest may be necessary, and the nutrition of paralyzed muscles must be maintained by the use of electricity. Retention of urine must not escape notice (see p. 810). The question of operative interference is considered at the end of this chapter.

The onset of symptoms of myelitis or meningitis indicates the use of counter-irritation : the actual cautery, mustard poultices, blisters, &c. Dry cupping may be of service. Under these circumstances perchloride of mercury in tincture of quinine or of bark may be given internally. At a more advanced period, and in some constitutions in which mercury is not well borne, the iodide or the bromide of potassium in full doses will be found highly beneficial, more especially when there are indications of the presence of inflammatory effusion causing pressure.

In the treatment of the condition of general nervous shock one of the most important indications is to procure sleep. For this purpose chloral, sulphonal and morphia may each be found most efficacious in different cases. Bromide of potassium or ammonium may be useful, but Page has clearly shown how much harm may result from the persistent use of this drug in large doses. The other indications are a period of freedom from the anxieties of business, the assurance that no serious injury of the spine has occurred, and general attention to diet with a course of tonics. Hysterical paralyses and other purely functional disorders must be treated on general principles.

WOUNDS OF THE SPINAL CORD.

These injuries may occur from stabs with pointed instruments ; from gun-shot violence ; or, most frequently, from the pressure of fractured vertebræ. In the latter form of injury there is an association of wound and compression, giving rise essentially to the same symptoms as if the cord were divided.

Symptoms.—When the spinal cord is *completely divided* or crushed subcutaneously, certain symptoms occur that are common to all cases, at whatever part of the cord the injury has been inflicted, provided it be not so high as to cause instant death. In the first place, there is *complete paralysis of sensation and motion* in all the parts below the seat of injury, though the mental state of the patient continues intact. The seat of injury may be diagnosed by the extent of the paralysis. Thus, there may be paralysis of all the parts supplied by the nerves of the sacral plexus, whilst those from the lumbar are not affected ; thus leading to the inference that the injury has been inflicted above the one and below the other set of nerves.

When the continuity of the cord is completely interrupted there is, at first, vaso-motor paralysis of the parts below the injury. Owing to the feebleness of the heart's action consequent on the shock of the injury, and to the want of movement in the paralysed muscles, there is soon some degree of venous stagnation, and the temperature of parts below the injury soon falls considerably, so as to give a distinct sensation of coldness to the hand. After a

days the vessels gradually recover their tone, and the congestion becomes marked. The condition of the reflexes in the parts below the injury is a t of great interest. It is universally agreed that during the period of k the superficial and deep reflexes are completely abolished. It has usually supposed that after the period of shock has passed, the reflexes return become exaggerated. The matter has, however, recently been brought ard by Bastian and Bowlby in separate communications read before the al Medical and Chirurgical Society. Bastian finds that in cases of *lete* transverse destruction of the cord by disease, the tendon reflexes are anently abolished. Bowlby has investigated the subject in numerous of transverse lesion of the cord by injury; he finds that the deep xes do not return, whilst the condition of the superficial reflexes varies, g in some instances permanently abolished and in others returning in a or a few weeks. The conclusion drawn from these observations is permanent abolition of the tendon reflexes is evidence that the trans- lesion is complete, and that return of these reflexes in an exaggerated ee proves that the lesion is only partial. Bastian suggests that the geration of the reflexes in partial transverse lesions is the result of the n of the cerebellum unrestrained by cerebral influence, and not, as has rally been supposed, of degenerative changes in the motor tracts below injury. After a time visible diminution takes place in the nutritive ity of the limbs, the circulation becoming feeble, with a tendency to us stagnation. The muscles waste to a certain extent, the skin assumes rty, cadaverous hue, and the cuticle usually exfoliates in branny flakes. ong, however, as the parts are in connection with a healthy portion of spinal cord, the graver trophic lesions, such as acute bed-sore, do not ifest themselves. Bed-sores, no doubt, commonly occur in these cases, they are due to the irritating effects of the urine and fæces involuntarily d by the patient, together with his want of mobility, and can usually be ented by skilful nursing.

open wounds of the spinal cord, such as result from gunshot injuries om stabs, the patient is exposed to the dangers of **septic meningitis myelitis.** These complications are commonly fatal. They are charac- ed by high temperature with pain in the back, and sometimes spasm or lity of the muscles of the trunk and limbs. The mischief may extend rds to the base of the brain, and cerebral symptoms may then manifest selves before death. Inflammatory softening of the cord in the neigh- hood of the wound is indicated by the paralysis extending upwards. litis following the injury is very commonly complicated by the formation ute bed-sores, which are rapidly fatal. This is due to the parts no longer g in connection with a healthy nerve-centre.

he general symptoms of paralysis following injury present important ifications, according to the height at which the cord is divided.

Injuries in the Lumbar and Lower Dorsal Region.—The cord ter- tes at the lower border of the first lumbar vetebra, consequently injuries w that point will affect only the spinal nerves forming the cauda na. All the nerves entering into the lumbar and sacral plexuses arise the part of the cord below the lower border of the eleventh dorsal bra. Injuries in this region consequently often cause complete paralysis ll the parts supplied from both the sacral and the lumbar plexuses; some-

times, however, the sacral alone is affected. When the injury affects the sacral plexus only, all the muscles below the knee, the flexors of the leg, the rotators, abductors, and extensors of the thigh are paralyzed ; but the extensors of the leg and the flexors and adductors retain their power. The muscles of the perinæum, the sphincter ani, and the bladder are also paralyzed. Sensation is lost in the gluteal region, the back of the thigh, the outer side of the leg and foot, the genital organs, and the perinæum. When the lumbar plexus is also affected, the whole lower limb is deprived of sensation and motion, and there is some loss of sensation about the lower part of the abdomen in the part supplied by the ilio-hypogastric, but the abdominal muscles retain their power of contraction. In some cases we find complete paralysis of the parts supplied by the sacral plexus, and irregular paralysis and loss of sensation in those supplied by the lumbar plexus. This is due to injury of that part of the cord from which the sacral plexus arises, with damage to some of the lumbar nerves which lie by the side of it, before they leave the vertebral canal. In an injury completely paralysing the sacral plexus, there is always relaxation of the sphincter ani, with consequent incontinence of flatus and, to a great extent, of fæces. In these cases the fæces are brought down into the rectum by the peristaltic action of the intestines, which is not suspended, being under the control of the sympathetic system, which communicates with the cord at a much higher level. The power of voluntary micturition and the sensation of fulness of the bladder are of course abolished. The act of micturition is supposed to be controlled by three centres in the lumbar region of the cord: an automatic centre maintaining the contraction of the sphincter, a motor centre in connection with the muscular coat of the bladder, and a sensory centre receiving the afferent nerves from the mucous membrane. These are in communication with the brain and with each other. In the normal act of micturition the sensation of fulness of the bladder is conveyed to the brain, from which an efferent impulse is sent to the motor centres, which inhibits the action of the automatic centre controlling the sphincter and stimulates the motor centre connected with the muscular coat of the bladder. In an injury of the cord it is possible that these centres may be destroyed. The bladder then becomes an inert bag, and the urine will dribble from it as soon as it has accumulated in sufficient quantity to overcome the mechanical resistance at the neck of the bladder and along the urethra. When the injury is at a higher level the urine is retained during the period of shock, but as this passes off the bladder usually empties itself periodically without the patient being conscious of what has occurred. This is due to the communication between the centres controlling micturition. As soon as the bladder reaches a certain degree of distension the centre controlling the sphincter is inhibited in its action, and that connected with the muscular coat is stimulated through the direct communications between these and the sensory centre. In these cases, therefore, the patient would not die from rupture of the bladder if no catheter were passed, but he would be constantly wet from the involuntary escape of urine, and thus the danger of fatal bed-sores would arise. A catheter is, therefore, usually passed at regular intervals, and as a consequence of this it often happens that after the first few days the urine becomes ammoniacal in odour and alkaline in reaction, from the formation of ammonium carbonate from the urea. This fermentation is believed always to be due to the introduction of micro-organisms into the

bladder from without either by means of the catheter or by direct extension up the paralysed urethra, which cannot perfectly empty itself of urine and mucus during the act of micturition as in a state of health. The decomposing urine soon sets up severe cystitis. The first effect of this is that, owing to the irritation of the sensory nerves, the act of automatic micturition is repeated at very short intervals till it amounts to almost constant dribbling. The urine becomes very foul, and is mixed with an abundant secretion of mucus and often some blood. Finally, it may lead to ulceration of the bladder, followed by septic poisoning by absorption from the raw surfaces; or the mischief may extend to the kidneys and terminate fatally by septic nephritis. Later in the case the bladder often becomes contracted, and constant dribbling of urine follows. In the early stages of these injuries to the cord, the penis will usually be observed to be in a state of semi-erection.

Patients who have met with injuries of this portion of the spinal cord may live on for many months, or even for a year or two, in a cachectic state; death then occurs usually from the formation of bed-sores, or from the effects of the diseased condition of the bladder.

2. When the cord is divided in the **Upper Dorsal Region**, about the level of the third dorsal vertebra, we have not only the train of symptoms that has just been mentioned as characteristic of this injury lower down, but respiration also is interfered with in consequence of paralysis of the greater portion of the expiratory muscles. The intercostal muscles, and those constituting the abdominal wall, no longer acting, the imperfect expiration is effected solely by the elasticity of the walls of the chest; and the purely muscular expiratory movements, such as sneezing and coughing, cannot be accomplished. In these cases, during inspiration, which is effected chiefly by the diaphragm, the ribs are depressed instead of being expanded and raised; and the abdominal wall, which is soft and flaccid, is protruded far beyond its normal limits. In consequence of the impediment to respiration the blood is not properly arterialized; and hypostatic pneumonia often causes death in two or three weeks.

3. When the injury is situated in the **Lower Cervical Region,** not only do all the preceding symptoms occur, but there is paralysis of the upper extremities as well; and, inspiration being entirely diaphragmatic, the circulation is speedily affected, the lungs become congested and œdematous, and the countenance suffused and purplish. If the cord have been crushed or divided immediately above the brachial plexus, there will be complete paralysis of the whole of the upper extremities; but if the injury be lower, the paralysis of the upper limbs may be only partial, those muscles which have their nerve origin above the lesion more or less escaping (see p. 791). There is this remarkable fact connected with injuries of the lower portion of the cervical spinal cord, that the temperature frequently presents a marked deviation from the normal standard. In some cases it rises very considerably, in fact to a higher point than has been noticed in any other surgical affection. Brodie found in one case that the thermometer marked 111° F. But in other cases again the temperature has been found greatly reduced, even to 81° or 82° F. No explanation of these extraordinary differences has as yet been discovered. In cases of injury of the cord in this situation, the patient, being unable to expel mucus from his lungs, usually dies from asphyxia in from forty-eight hours to a week.

When the division of the spinal cord takes place **above the Origin of the Phrenic Nerves** opposite to or above the third cervical vertebra, instantaneous death results from the paralysis of the diaphragm, as well as of the rest of the respiratory muscles, inducing sudden asphyxia.

It necessarily happens in **partial division of the cord** that the symptoms are less clearly marked. In many of these cases resulting from fracture or dislocation, the symptoms due to actual injury of the cord are complicated with those of pressure on one or more nerves in the intervertebral foramina. When this occurs there is often pain in the line of the nerve, and, if it be in the dorsal region, a sensation like a painful girdle round the waist. The most definite of these injuries are met with in partial division of the cord by a stab. In these cases it has occasionally happened that the weapon has divided one of the lateral halves of the cord. Under these circumstances the parts on the same side of the body below the seat of the lesion are paralysed; this necessarily follows from the fact that the motor fibres have their decussation chiefly in the medulla, although to a minor extent in the cord. Brown-Séquard was one of the first to lay down the rule that in such cases sensation is lost on the side opposite to the section, and that hyperæsthesia exists on the paralysed side. This distribution of the anæsthesia was explained by the then generally accepted view that the decussation of the sensory fibres took place along the whole length of the cord. At the present day, however, there is an increasing tendency towards the belief that the chief decussation of the sensory fibres takes place in the bulb, and that sensory impulses are carried up the cord chiefly on the same side as that upon which the posterior roots enter. This view is supported by the recent experiments of Mott and of Horsley and Gotch, and is not altogether without clinical evidence in its favour. It thus appears that there is good reason to believe that the condition following hemisection of the cord is not so clearly defined as was formerly supposed, and detailed investigation of these unusual cases must prove of the greatest value.

FRACTURE AND FRACTURE-DISLOCATION OF THE SPINE.

Fracture of the spine may occur without displacement, and very rarely dislocation occurs without fracture, but in the large majority of cases the two conditions are associated and a **Fracture-dislocation** is the result.

This injury may occur either by the application of direct violence, or by a violent twist or bend of the body forwards. Direct violence, as a blow, fall, or gunshot injury, may of course fracture the spine at any part and almost to any extent, in some cases merely detaching a spinous process, in others splintering and comminuting several vertebræ and lacerating or dividing the spinal cord. Fracture of the spine from a violent but forcible bend of the body forwards occurs chiefly in the cervical region. It is usually produced by a person falling from a height on the head, the body being bent forcibly forward so as to drive the chin against the sternum. This accident often happens in falls from horseback, or in taking a "header" into shallow water. In some cases it has occurred from a person sitting on the top of a vehicle having his head forcibly bent down whilst passing under an archway. In these accidents there is usually extensive rupture of the spinal ligaments with displacement of the bones, as well as fracture.

In some cases of even very extensive fracture there may be no appreciable

displacement; usually, however, some change of position ensues, in many cases to such an extent as to compress or lacerate the spinal cord. The mode of occurrence of the fracture will influence the amount of displacement. If the fracture be through the arch, or consist in a simple detachment of the spinous process by a fall or a blow on the back, there may be no displacement. If it occur from a fall upon the head, or by a forcible flexure of the neck and body forwards, as when the body is compressed between the top of a van and an archway, there will probably be great displacement and perhaps separation of the articulating surfaces of contiguous vertebræ. In these cases the upper part of the spine is almost invariably displaced forwards.

The **Signs** of this injury vary very greatly, and depend in a great degree upon the extent of the displacement. If this be inconsiderable, it may be extremely difficult, and even impossible in some instances, to pronounce with certainty whether the spine has been broken or not; the more so if the fracture do not implicate the body of the vertebra. If, on the other hand, the displacement affect the axis of the column or compress the cord, the symptoms are so marked that diagnosis is easy. They are of two kinds: those due to injury of the bone, and those dependent on injury by compression or laceration, or both, of the spinal cord.

The **Local Signs** are usually pain at the seat of injury, greatly increased by pressure on, or motion of the part; inequality of the line of the spinous processes, with depression of the upper portion of the spine, and corresponding prominence of the lower. There is an inability to support the body in the erect position, and to move the spine in any way; hence, when the upper portion of the column is injured, the patient holds his head in a stiff and constrained attitude, fearing to turn it to either side.

The **General Symptoms** of fracture of the spine are dependent upon the injury which the cord has received. If the fracture have not implicated the spinal canal, as when only the tip of a spinous process has been broken off, or if it be unattended with displacement, although it may traverse the body and arches, no symptoms depending upon injury of the cord need exist. But even in these cases there may be transitory paralysis, owing perhaps to the concussion to which the cord has been subjected at the moment of injury; and occasionally a sudden movement by the patient will bring on displacement, by which the cord is compressed and all the parts below the injured spot are paralysed. A woman was admitted into University College Hospital with an injury of the neck, the nature of which could not be accurately ascertained. She was in no way paralysed, but kept her head immovable in one position. A few days after admission, whilst making a movement in bed, by which she turned her head, she fell back dead. On examination, it was found that the spinous process of the fifth cervical vertebra had been broken off short, and was impacted in such a way between the arches of this and the fourth as to compress the cord. This impaction and consequent compression probably occurred at the time of the incautious movement, thus causing immediate death. When there is only partial displacement, there may be but incomplete paralysis of the parts below the injury—of one arm, one leg, &c. In these cases there is usually great pain at the seat of fracture, and extending from it along the line of junction between the paralysed and the sound parts round the body or along the limb. This symptom, which is of great importance as exactly defining the seat of injury, is due,

as I found in dissecting a case of fracture of the sixth cervical vertebra under my care, to the fractured bone compressing and irritating the nerve that issues from the vertebral notch opposite the seat of injury.

When the cord is implicated, the symptoms will vary according to the seat of the injury and the extent of the damage. For a detailed account of the symptoms presented by injuries of the different portions of the cord, the reader is referred to the sections on "Intraspinal Hæmorrhage" (p. 789) and "Wounds of the Spinal Cord" (p. 802).

If the spine be fractured by indirect violence, as by the head being forcibly bent down on to the chest as the patient is driving under an archway, and a fracture be thus occasioned through the lower cervical or upper dorsal portion of the column, we shall find that the cord being lacerated, and compressed transversely in one part only, the ordinary symptoms of division of the cord at that part will be presented, the patient being paralysed below the seat of injury (see p. 791).

In a large proportion of cases of fracture of the spine, there is such displacement of the bone as to compress the whole thickness of the cord, and thus to occasion complete paralysis of motion and sensation in the parts below the seat of injury. This paralysis resembles that which arises from simple division of the cord, but is followed by greater impairment of nutrition, as shown in wasting, cachexy, and a tendency to sloughing. The reason of this difference is, that in fracture the cord is not simply compressed or divided, but is continuously irritated by the edges of broken bone, and thus not only becomes incapable of healing, but is kept in a state of chronic irritation and inflammation. If the fracture be above the origin of the phrenic nerve, respiration will be arrested and the patient will die instantaneously.

Prognosis.—The danger from fracture of the spine depends on the amount of injury sustained by the cord, and the situation of the injury. Thus, if there is no displacement of the broken vertebra or injury to the cord, union will take place, and the patient recover perfectly; but fractures of the spine through the bodies of the vertebræ, with displacement and compression of the cord, are most commonly fatal.

When the fracture occurs in the middle or lower dorsal regions, so that the lower portion only of the cord is injured, the patient may live for many years, even though the cord is completely severed and the spinal canal obliterated by the displacement, and by the new bone formed in the process of repair. There is a specimen in University College Museum which well illustrates this fact (Fig. 313). The patient was a man who, at the age of thirty-two, fell fifty feet from a tree. He sustained a fracture of the spine, with the unusual displacement of the upper fragment backwards. The fracture became firmly consolidated, and he lived for nine and a-half years, completely paralysed below the middle of his body. There was no sloughing of the hips or back, and the vesication caused by blisters, which were for some reason applied to the paralysed parts, healed without difficulty. After repeated attacks of cystitis, inflammation spread to the kidney, and he died of septic pyelo-nephritis. The specimen shows ossification of the dura mater below the seat of fracture.

Even when the injury is in the cervical region, recovery may take place, although the case may appear most unpromising. I have known at least four cases in which recovery has occurred after fracture of the lower cervical vertebræ, with paralysis more or less complete from the neck downwards. In

one of these the neck was broken by a fall in kangaroo-hunting, and the patient, who was young and active, after being paralysed for eleven months, made a fair though not complete recovery—some paralysis, with wasting, of the extensors of the hands being left.

When *death* takes place, it may occur in three different ways. It happens primarily as the immediate result of the injury, in all those cases in which the fracture is above the origin of the phrenic nerve. It occurs secondarily and indirectly, at a more or less remote period, as the result of changes in the body dependent on permanent separation of the parts below the injury from the nervous centres above. At the seat of injury, compression, or crushing, inflammation is necessarily developed; thence it may spread along the membranes, giving rise to effusion into the canal, and into the cord itself, causing softening. It is, doubtless, by the gradual extension upwards of this secondary inflammatory softening that death is ultimately occasioned in many

Fig. 313.—Fracture through the lower dorsal and first lumbar vertebræ, with displacement backwards of upper fragment.

Fig. 314.—Crush of Cord. The result of a Fracture of the Spine.

cases. Thus, an injury in the cervical region, which was not immediately fatal, may ultimately prove so by the mischief extending to the origins of the phrenic nerves, and so arresting respiration. Many also perish from bedsores, and a very large proportion of cases prove fatal from pyelo-nephritis secondary to cystitis, with decomposition of the urine.

The **Treatment** is simple enough when the patient escapes without implication of the cord. It is evident that in such cases no attempt at reduction should be made, lest by dislodgment of the fragments the cord be injured. The patient must be placed flat upon his back, and the strictest possible rest maintained. König of Göttingen has recommended, in cases of fracture in the dorsal or lumbar region without damage to the cord, that Sayre's plaster of Paris jacket should be applied as early as possible. He has himself applied it on the fourth day, and Berkeley Hill at the end of thirty hours. In these cases the patient was suspended by the arm-pits, and at the same time supported by assistants, care being taken not to lift him sufficiently high to raise

the feet from the ground. Extension under these circumstances, however, cannot be devoid of danger, and the better plan would be to apply the apparatus in the way recommended by Walker of Peterborough. He first puts on the patient a flannel vest without sleeves, or if there is any difficulty in doing this, a piece of soft flannel wide enough to reach from the axilla to the hip may be passed under the back, and carefully sewn down the front, so as to leave no creases. A number of strips of muslin bandage, cut of the proper length to encircle the body, and to overlap for a few inches, are then prepared. These are dipped in a mixture of plaster of Paris, 1 lb., water, ℥viij, with ℥j of mucilage of gum acacia added, to delay the setting. They are then quickly spread on a bed covered with a mackintosh sheet, each overlapping that above for two-thirds of its width. They must be thus arranged till a sufficient width is reached to extend from the patient's axilla to midway between the crest of the ilium and the trochanter; and a sufficient number of strips should be used to make the whole about six layers thick. The patient is then carefully lifted and laid on the bandages, which are folded over and rubbed smooth, as in an ordinary plaster of Paris bandage. A pad should be put over the epigastrium, which can be withdrawn when the splint is firm. In the cases treated by König, and in Hill's case, the results were most satisfactory. Two cases have, however, been recorded in which the patient could not bear the bandage, but no harm was done by the attempt to use it.

Another plan of treatment, originally recommended by Wormald, is to raise the patient carefully up, and place beneath him a large sheet of softened gutta-percha, and so to mould a splint to the back.

In *cases in which the cord is injured*, attempts at the reduction of the fractured and displaced spine must not be lightly undertaken. It may prove unsuccessful, greatly increase the sufferings of the patient, or hasten his death. In cases of injury to the lower cervical vertebræ, it would rarely, if ever, be proper to make such attempts. In the upper and middle dorsal they would not be likely to succeed, owing to the want of mobility of this part of the column. In the lower dorsal and lumbar regions they would be less dangerous, and more likely to prove advantageous.

All our efforts must be directed to prolonging life, if the fracture be in such a situation (at any point below the upper dorsal vertebræ) as to hold out a prospect of continuance of life for a few weeks or months. Means must be taken to prevent the occurrence of sloughing of the nates, an accident that is commonly fatal. The patient should be laid on a water-bed, cushion, or mattress, and must be kept scrupulously clean. If possible, a mattress should be obtained, with a segment that will pull out to admit the bed-pan, or some such arrangement to avoid disturbance of the spine. Every precaution should be taken to prevent the supervention of cystitis. For this purpose the urine must be drawn off with a catheter, regularly, at least twice in the day. The catheter should, before being used, be dipped in a vessel containing a 1 in 20 solution of carbolic acid and lubricated with carbolic oil (1 in 10). If, in spite of these precautions, ammoniacal decomposition of the urine should take place, the bladder must be washed out with an antiseptic solution every time the water is drawn off. Solution of permanganate of potash, or three grains of quinine, with three minims of dilute sulphuric acid to the ounce of water, will be found the most efficient preparations. (See Cystitis.) If, as usually happens after a time, the bowels become confined, relief must be afforded by

castor-oil or turpentine enemata. A nourishing diet must be administered and perfect rest in one position enjoined. In this way life may be maintained for a considerable length of time, and bony union of the fracture may take place, though the patient may not recover from the paralysis, and may die eventually from the effects of the injury. But in some cases a much more satisfactory result is obtained; the patient gradually gains power in the paralysed parts. Much assistance will then be afforded by making him wear, as soon as the fracture is sufficiently consolidated, the apparatus shewn in Fig. 315, consisting of a firm pelvic band, with a strong iron rod shaped to the spine, and running as high as the vertex, having padded transverse arms to support the head and shoulders, and the whole attached to a stout leather case moulded to the back and shoulders. If not applied primarily the plaster of Paris jacket will always be found of great service in the later stages of the case.

Fig. 315.—Apparatus for Fracture of the Spine.

Dislocations of the Spine.—On looking at the arrangement of the articular surfaces of the vertebræ, the very limited motion of which they are susceptible, and the way in which they are closely knit together by strong ligaments and short and powerful muscles, it is obvious that dislocations of these bones must be excessively rare. So seldom, indeed, do they occur that their existence has been denied by many Surgeons. Yet there are several instances on record which prove that such accidents may happen. The cases that have been met with have usually been associated with partial fracture, but this complication is not necessary. In all, the displacement was incomplete; and, indeed, a complete dislocation cannot occur. Fracture may occur anywhere in the spine, but dislocation without, or with very slight, fracture is met with only in certain situations. Dislocation of the spine may occur in the following parts:—1. Between the occiput and atlas. This is very rare. 2. Between the atlas and axis. This, though rare, is much less so than the preceding, and may occur with or without fracture of the odontoid process; when the odontoid process is broken, death at once ensues. 3. Dislocation between the second and third cervical vertebræ is very rare—as rare as dislocation between the atlas and axis. 4. Dislocation generally happens somewhere between the fifth and seventh cervical vertebræ. Dislocation without fracture can scarcely occur in the dorsal region, and there is no recorded case of a pure dislocation in the lumbar region.

In Fig. 316 we have an example of dislocation of the fifth from the sixth cervical vertebra, with the separation only of a scale of bone which was adherent to the intervertebral fibro-cartilage. The patient had fallen on his head from a van and died of asphyxia in twenty-four hours.

The spine may be so seriously injured that dislocation is at any moment imminent, and yet the patient may live for some days before the displacement, by which the cord is compressed, occurs. A man was admitted into University College Hospital, who had been crushed by falling between the platform and a train in motion. Amongst other severe injuries he had paralysis of the circumflex and musculo-spiral nerves of the left arm, but no hyperæsthesia. On the third day, whilst being moved in bed, his head fell to one side, and he

suddenly died. On examination after death, it was found that the second cervical vertebra, carrying the atlas and head with it, had been dislocated from the third (Fig. 317); the connecting ligaments being completely torn through on the left side, so that the head falling to one side had caused fatal compression of the cord.

Dislocation of the Occipital Bone from the Atlas has been described by Lassus, Paletta, and Bouisson. In the case by Lassus death ensued in six hours, and the right vertebral artery was found to be ruptured. In Paletta's case, the patient is said to have lived for five days, but the report is so incomplete that little value can be attached to it.

Dislocation of the Atlas from the Axis is of more frequent occurrence. It may happen with or without fracture of the odontoid process. In either case, the atlas is carried forwards and the spinal cord thus compressed.

Fig. 316.—Dislocation between the Fifth and Sixth Cervical Vertebræ.

Fig. 317.—Dislocation of the Axis from the Third Cervical Vertebra.

This accident is said to have been caused by a person in play lifting a child off the ground by its head; the combination of rotation and traction in this movement being especially likely to occasion the accident. For the same reason, it has been met with in those who have been executed by hanging. Death would probably be instantaneous in these circumstances. It has, however, been stated that, in dislocations of this kind, life has been saved by the Surgeon placing his knees against the patient's shoulders, and drawing or twisting the head into position. This, however, I cannot believe possible if the displacement has been complete, as death must be instantaneous; the cases of supposed dislocation and reduction have probably been instances of concussion of the cord with sprain of the neck.

Dislocation of any one of the five Lower Cervical Vertebræ may occur. The third vertebra is least frequently dislocated; the fifth is more commonly displaced (Fig. 316). These injuries are usually associated with fracture; sometimes, though rarely, they happen without this complication. In these dislocations, as in those that have already been described, the dis-

placed bone carries with it the whole of that portion of the vertebral column which is above it.

In dislocations, the articulations between the two vertebræ are torn open. The supraspinous and interspinous ligaments, the ligamenta subflava, and the common posterior ligament, are torn through, so that the spinal canal is opened. The intervertebral fibro-cartilage may be torn, or it may be entire, a scale of the body of the subjacent vertebra being detached with it. When the spine above the dislocated part is bent forwards, a wide gap is visible posteriorly, at the seat of injury.

Causes.—The causes of dislocation are numerous, and the following may be given as examples. A person standing in a cart and driving under an archway finds, too late, that he is too tall to clear the arch: he bends forwards, but miscalculating the distance, his head is pressed violently downwards. A person takes a "header" into shallow water; his head comes against the bottom, is forcibly flexed, and his spine is broken or dislocated. Such accidents are not very unfrequent. I have seen several cases of paralysis and death resulting from this kind of injury.

These accidents most commonly happen from forcible flexion of the neck, though traction and rotation conjoined have occasioned them. In a case of luxation of the sixth and seventh cervical vertebræ, recorded by J. Roux, the accident happened to a sailor plunging into the sea for the purpose of bathing, and coming head foremost against a sail which had been spread out to prevent the attack of sharks; he died on the fourth day. In a patient of mine, who fell out of a window in such a way that the head was doubled forwards upon the chest, and who was brought to the Hospital with supposed fracture of the spine, we found after death, which occurred on the fifth day, that the seventh cervical vertebra, carrying with it the upper portion of the spine and the head, had been dislocated forwards from the first dorsal, the intervertebral substance detaching with it an extremely thin and small layer of bone from the body of the seventh vertebra. There was a wide gap posteriorly between the laminæ. There was no fracture about the articular processes, which were completely separated from one another. In the instance already referred to, in which a man fell on his head from a van, and death resulted in twenty-four hours, a similar displacement was found of the fifth from the sixth cervical vertebra, with compression of and hæmorrhage into the substance of the medulla, and disorganization of it to the extent of nearly an inch opposite the seat of dislocation, where it had been injured by the forward pressure of the dislocated vertebra.

In the **Dorsal Region**, dislocation of the spine, though excessively rare, may occur; seldom, however, without being accompanied by fracture. The last dorsal vertebra has several times been found dislocated from the first lumbar with rupture of the intervertebral fibro-cartilage. In these cases, however, there has usually been found fracture of the transverse processes of the first lumbar vertebra, or, as in an instance recorded by Charles Bell, fracture of its body.

The **Symptoms** caused by dislocations of the spine are, like those of fracture, dependent on the degree and seat of the injury inflicted on the spinal cord. And death will ensue at varying periods, according to whether the dislocation is above or below the origin of the phrenic nerves, in accordance with the rules laid down at p. 809.

The **Diagnosis** between a dislocation and a fracture of the cervical spine is not easily made. But there is one symptom which, according as it is present or not, may throw much light on this point. This is the occurrence of pain, amounting to hyperæsthesia, along the line of junction between the paralysed and the unparalysed parts. In fracture this will commonly be found to be present (p. 807). In dislocation, where the nerves are not irritated or lacerated in their exit through the spinal column, it is absent.

The **Treatment** of dislocation of the spine resembles in all important respects that of fracture of the vertebral column. *Reduction* has, however, been effected in a sufficient number of cases to justify the attempt being made when the danger is imminent.

Dislocation of the Transverse Processes of the Cervical Vertebræ occasionally occurs. The patient, after a sudden movement, or a fall on the head, feels great pain and stiffness in the neck, the head being fixed immovably, and turned to the side opposite to that on which the displacement has occurred. In these cases I have known *Reduction* effected by the Surgeon placing his knee against the patient's shoulder, drawing on the head, and then turning it into position, the return being effected with a distinct snap.

Wound of the Theca Vertebralis.—Holmes has recorded two cases in which this accident happened from the stab of a penknife in the lumbar region; in one of them the patient died. The only characteristic sign was the escape of cerebro-spinal fluid in large quantities from the wound.

Operation in Injuries of the Spine.—As the fatal result of fracture of the spine, with compression of the cord by the broken vertebra, or by extravasated blood, is almost inevitable, the idea has naturally suggested itself to Surgeons that life might be prolonged, and health perhaps restored, if the same operation were extended to the spine which is successfully employed in analogous cases of injury of the head; viz., the elevation and removal, if necessary, of the depressed portion of bone. This operation, originally proposed by Heister, was first performed by Louis and Cline. In all cases of compound fracture the wound must be enlarged and any fragments removed. The results of operation in cases of fracture have not been very encouraging; but, as fracture of the spine with serious lesion of the cord is almost invariably fatal, and as the evil consequences of the fracture are occasionally dependent not only upon the primary lesion of the cord, but on the secondary inflammatory processes set up in it by the continued irritation of the fractured fragments, the Surgeon is surely justified in attempting the removal of this source of certain misery and impending death by the only means in his power—operative procedure; the more so as the operation is not necessarily dangerous, does not appear often to have hastened death, and has certainly, in some cases, afforded relief, the paralytic symptoms disappearing to a great extent, and the patient being able to move limbs that were previously motionless.

Unfortunately in the great majority of cases the fracture of a vertebra is through the body and not through the arches. Little more than temporary relief can be expected from the removal of the pressure from behind by cutting away the arches, when the cord is partially divided and lacerated by a rough and jagged edge of the broken body of a vertebra thrust back against it. It is when the arches only are fractured and displaced—a rare

condition it is true—that permanent good may be expected to follow the operation.

We have already seen that in some cases of fractured spine the symptoms are due to hæmorrhage within the spinal canal, and that such hæmorrhage may occur independently of fracture. Under these circumstances, operation may be undertaken for the relief of pressure. The same remark applies to those rare cases in which symptoms arise at a later date from the occurrence of meningitis with inflammatory effusion. Thorburn strongly advocates operation in injuries of the cauda equina, that is, injuries below the first lumbar vertebra, if spontaneous recovery have not occurred after about six weeks. From the study of some two hundred cases in which operation has been undertaken for injury of the spine, Thorburn concludes that little good is likely to result, except in the three conditions already mentioned—fractures of the spines and laminæ, intraspinal hæmorrhage, and injuries of the cauda equina. The fact that recovery is rare, even when the displacement of the bones which damages the cord is momentary, will readily explain the unfavourable results which usually follow the relief of pressure on the cord by operation, for the cord itself has usually been damaged beyond hope of repair.

The operation of **laminectomy** is performed as follows:—The patient is turned on to the side, or slightly on to the face. An incision, from three to five inches in length, is made over the spines, and the soft structures are separated from the spines, neural arches and articular processes with a scalpel and periosteal elevator. Additional room may be obtained by making short transverse cuts in the vertebral aponeurosis. All bleeding vessels are tied, and the free general oozing is arrested by plugging the wound with cotton wool soaked in a hot solution of perchloride of mercury (1 in 1,000). Each of the exposed spines is now tested to ascertain if any fracture exists, and any completely or partly separated bone is removed. Should a fracture be detected, one or more spines must be cut away with strong bone forceps, and the ligamenta subflava very carefully divided with a scalpel and forceps. The pin of a trephine is now applied to the surface left by removing a spine, and the lamina on each side notched. The lamina is now cut away very carefully with bone forceps, and others are similarly removed if necessary. The theca is thus exposed, and bleeding is arrested by gentle sponge pressure.

If no cause of the compression be found outside the theca, the latter must be carefully opened in the middle line. In cases of fracture a bent probe or searcher may be passed beneath the cord to see if any fragments lie in front of it. The theca may be closed with fine catgut sutures; deep sutures are inserted through the muscles and skin. A small drainage tube should be placed in the superficial part of the wound for 24 hours, and the deepest part of the dressing should consist of a longitudinal pad on either side of the incision. It is scarcely necessary to insist upon the strict antiseptic precautions which must be observed in all operations upon the spinal canal; otherwise a fatal complication may be added in the form of septic meningitis and myelitis.

CHAPTER XXVI.

INJURIES OF THE FACE AND ADJACENT PARTS.

FACE.—Cuts about the *Cheeks and Forehead* are of common occurrence. These injuries present nothing peculiar, except that the structures of the face show the same ready disposition to repair that characterizes the scalp when injured.

In the *Treatment* of these wounds, it is of much consequence to have as little scarring as possible. The edges, after being well cleaned, should be brought neatly into apposition by one or more wire or catgut sutures deeply applied to take the chief strain, and a number of fine horsehair interrupted sutures to bring the edges in accurate apposition. If the wound penetrate to the nose or mouth, so that there will be sufficient drainage from the mucous surface, the skin may be covered with collodion; if not, a dry wool dressing is the best.

When the wound is in the neighbourhood of the eyelids, especial care must be taken to prevent suppuration, lest the contraction of the cicatrix produce eversion of the lid. In those cases in which a portion of the nose or lip has been lost, much may be done to repair the deformity by properly conducted plastic operations, such as will be described in Chapter LVIII. The bleeding, which is usually very free in wounds of the face, is easily arrested by ordinary means.

If the *Lip be cut from within*, by being struck against the teeth, the coronary artery may be divided, the patient swallowing the blood that flows into the mouth. Some years ago, a man was brought to the Hospital, drunk, and much bruised about the face. Shortly after his admission he vomited a large quantity of blood, which was at first supposed to proceed from some internal injury; but, on examining his mouth, it was found that the blood came from a wound of the coronary artery of the lip.

PAROTID DUCT.—It occasionally happens in wounds of the cheek that the parotid duct is divided, in consequence of which the wound does not close, and a trickling of saliva takes place upon the outside of the cheek; a **Salivary Fistula**, which is a source of great disfigurement and inconvenience, being established. The surface surrounding it is puckered and somewhat excoriated, and the fistula opens by a granulating aperture.

If from its anatomical situation a wound is known to have divided the parotid duct, the formation of a fistula may be prevented by bringing the skin surface accurately together, leaving the mucous aspect of the wound freely open and covering the surface with a piece of lint dipped in collodion. If the divided ends of the duct can be seen in the wound it has been recommended to pass one end of a fine piece of silver wire down into the mouth and the other up the duct towards the parotid for a short distance and then through the mucous membrane into the mouth; the two ends are then knotted together

inside the mouth and the external wound closed. By this means the continuity of the duct is maintained while the wound heals, and at the end of a week the silver wire may be withdrawn by dividing the loop in the mouth. Should a fistula form it must be treated as described in Chapter LV.

Besides fistula of the Stenonian duct, other fistulous apertures may be formed in the cheek, as the result of injury or disease, allowing the escape of a small quantity of saliva. These openings are always closed with difficulty; the edges becoming callous, and not readily taking on reparative action. Closure may be effected in some cases by cauterization with nitrate of silver, or with a red-hot wire. In other cases, the electric cautery may prove successful. If, however, the opening is free, with much indurated structure about it, it may be necessary to excise a portion of the edges before bringing them together.

Fig. 318.—Ear-Scoop.

NOSE.—**Foreign Bodies**, such as pebbles, beads, dried peas, &c., are occasionally met with in the nostrils of children, having been stuffed up in play and become so firmly fixed as to require extraction by the Surgeon. In most cases a bent probe or an ear-scoop will remove the impacted body most easily. If it be large and soft it may often be easily removed with a pair of forceps, but a hard smooth body is almost sure to be pushed further up with these instruments. It is always best to administer an anæsthetic, otherwise the involuntary movements of the child will greatly add to the difficulties of the Surgeon. If the body be not removed it may give rise to chronic purulent catarrh or even to disease of the bones.

The EARS are not unfrequently *wounded* in injuries of the head and scalp; a portion of the external ear being sometimes torn down and hanging over the side of the face. In these cases, as in scalp injuries, the part should never be removed, but, however lacerated and contused, should be cleaned and replaced by means of a few points of suture. When the cartilaginous portion of the ear is divided, nice management is usually required in effecting perfect union.

Foreign Bodies are often pushed into the ears of children. When pointed or angular, such as pieces of stick, they may readily be extracted with forceps provided they can be clearly seen; but when round and small, such as pebbles or beads, they are not so easily removed.

The foreign body may occasionally be removed by passing the bent ear-scoop round it. In some cases I have found an instrument (Fig. 318) made by Coxeter on the model of Civiale's urethral scoop, useful in extracting a foreign body from the ear. It can be introduced straight and passed beyond the body, when, by the action of a screw in the handle, the scoop is curved forwards, and so enables extraction to be readily effected. But, as a rule, it is bad practice to attempt to extract foreign bodies from the ear by means of instruments; in the majority of cases the offending body is best removed by syringing the ear with tepid water, injected in a full stream by means of a large brass syringe, the pinna being drawn up so as to straighten the external meatus. In this way the bead or pebble is soon washed out by the reflux of the water striking against the tympanum. It may be laid down

as a good general rule, that if a round or oval body cannot be dislodged by syringing it will not be removed by instruments; and if the proper use of the syringe do not suffice, it is better to leave matters alone, and to allow the foreign body to become loosened, when it can be easily syringed out, than to poke instruments into the ear with the view of forcibly extracting it. These attempts are ill-advised; and I have known death, from inflammation and suppuration in the middle ear extending to the meninges of the brain, to follow from prolonged and unsuccessful efforts at the extraction of a pebble from the ear.

ORBIT.—*Injuries of the Orbit* may be dangerous, either to the brain or to the eye. Deep wounds are usually directed upwards, so that the roof of the orbit is the part most likely to suffer. The gravity of such a wound may not be recognized until meningitis sets in, for the small skin wound may rapidly heal, or may even be wanting if the penetrating weapon have passed between the lid and the eye. The optic nerve may be divided without damage to the globe itself, and thus immediate and permanent blindness may result. Foreign bodies in the orbit are easily overlooked and may cause trouble for months before their presence is suspected.

Orbital abscess is sometimes the result of a wound, with or without the retention of a foreign body. It may run an acute course, or it may be extremely chronic and strictly localized, thus simulating a tumour. In the acute form there is swelling of the lids, almost erysipelatous in character, with protrusion of the eye, loss of movement and intense widespread throbbing pain. The eye may also be displaced vertically or laterally according to the position of the pus. The widest interval between the globe and the orbital margin is, therefore the point at which an incision should be made. A narrow-bladed knife, held with its back towards the globe, should be passed deeply into the orbit. The early evacuation of the pus is very essential lest blindness result from the prolonged pressure upon the optic nerve, or lest the inflammation spread backwards and set up purulent meningitis.

EYE-LIDS.—These may be extensively cut or lacerated without damage to the eye itself, but a careful examination of the eye should always be made when there is any fear of the lid having been penetrated. Wounds of the lids unite readily if sutured, but great care must be taken that the margin of the lid be brought into accurate apposition. For this purpose a fine suture should first be inserted in the free border of the lid, and then a row of others placed in the skin. If there be much gaping of the wound, a deeper suture or a fine pin with a figure-of-8 turn of silk may be used.

EYE.—**Injuries of the Conjunctiva.**—The most common minor injury of the eye is the impaction of a minute fragment of some foreign body in the cornea or conjunctiva. The foreign body will most often be found imbedded in the lower half of the cornea, as this part is most exposed in the palpebral fissure. There is usually much pain and discomfort, aggravated each time that the patient closes the eye when the upper lid is scratched by the offending particle. The eye waters freely and is intolerant of bright light; the pupil may be smaller than the other (congestion myosis). The removal of a foreign body from the eye may be effected as follows. The patient should be seated. The Surgeon stands behind, with the patient's head resting against his chest. After dropping some 2 per cent. solution of cocaine into the eye, the Surgeon concentrates the light of a lamp on to the

cornea with a convex lens held with the thumb and index finger of the left hand, the lids being steadied and held gently apart with the other finger of the same hand. The best instrument is a fine needle such as is used for the discission of cataract membranes, as this causes less injury to the corneal epithelium than the ordinary "spud." The patient is directed to look with both eyes at some fixed object, and the foreign body is removed by inserting the point of the needle beneath its edge and gently lifting it out of its bed. Should no foreign body be found on the cornea, the patient should be directed to look downwards whilst the upper lid is everted over a probe. The foreign body most usually adheres to the lid about an eighth of an inch from the margin. Some castor oil or simple ointment should be put between the lids and the eye kept bandaged for a day. If much irritation has already been produced it is advisable to use atropine drops once or twice.

Burns by acid, caustic alkalies, lime, and molten metal are amongst the most disastrous injuries to which the conjunctiva is liable. The ultimate damage to the edge is often much greater than would seem probable immediately after the injury. A fresh burn of the cornea often appears only as a clear slightly depressed area interfering little with vision, whilst the resulting leucoma may be so dense as to render the eye practically useless. Burns of the conjunctiva may lead to extensive adhesion of the lids to the globe—*symblepharon*. The immediate treatment of an eye injured by escharotics should be to alleviate the pain and orbicular spasm by the use of a 2 per cent. solution of cocaine, and after carefully removing all solid particles, to wash out the conjunctival sac. The chemical action of an acid or alkali may be arrested by the use of a weak neutralizing solution if the case be seen immediately after the accident. After washing out the conjunctival sac, a few drops of castor oil, or better, some simple ointment with lanolin as a basis, should be put inside the lids to lessen the friction of the raw surfaces on one another. Opium in some form will probably be needed at night, as the pain is always severe. A pad of absorbent wool should be kept lightly applied over the eye with a bandage. Frequent irrigation with warm boric lotion and the use of a simple ointment will be required. Any attempt to prevent the formation of adhesions between the globe and lids by breaking them down frequently is quite futile, and only delays the healing. When cicatrization is complete, much may often be done by plastic operations to remedy the deformity produced by cicatrices.

Contusions of the Eyeball.—A severe blow upon the eye, as by a racket ball or the cork of a soda-water bottle, may, without injuring the outer tunics, cause serious damage to the deeper structures. Temporary paralysis of the sphincter muscle of the iris may cause a dilated inactive pupil, whilst partial or complete paralysis of the ciliary muscle may be evidenced by loss of power of accommodation for near vision. The iris may be torn away from some part of its peripheral attachment, leaving a spindle-shaped gap, or it may be fissured radially at its pupillary margin. *Hæmorrhage* may take place into the anterior chamber, the vitreous, or the retina. Hæmorrhage into the anterior chamber (*hyphæma*) is often, but not always, associated with rupture of the iris; the blood may come from the ciliary processes, and finding its way through the pupil, settles in the lower part of the anterior chamber. Absorption of the effused blood usually occurs rapidly. Hæmorrhage into the vitreous may be so profuse as to cause immediate blindness. If the pupil be

dilated and light focussed on to the eye with a convex glass, a red mass is seen behind the lens, whilst on ophthalmoscopic examination there is found to be complete absence of the normal red fundus reflex. If the amount of effused blood be small, it will be recognized with the ophthalmoscope as fine webs floating in the vitreous. Blood effused into the vitreous is usually absorbed slowly, and some permanent opacity may result. Hæmorrhages into the retina are, as a rule, multiple, and rarely of large size; they usually disappear quickly.

Dislocation of the lens may follow a blow on the eye, as the result of tearing of the suspensory ligament, the amount of displacement varying with the extent of the rupture of the ligament. In the slighter cases in which one edge of the lens is tilted forwards, the nature of the injury is recognized by the pushing forwards of the iris at this spot, whilst in its opposite part the iris is tremulous on account of the loss of the support of the lens; pendulum-like oscillations of the lens may be observed when the head is moved.

Complete displacement of the lens may occur, forwards into the anterior chamber, or backwards into the vitreous; in the latter case the whole iris is tremulous, when the eye is sharply moved from side to side. After complete displacement, the lens may remain clear for a long period, but more often it sooner or later becomes opaque. Dislocation of the lens forwards is especially likely to be followed by acute glaucoma. If the case can be kept under observation, it is probably better not to attempt to remove the dislocated lens so long as the eye remains quiet, but if the eye becomes painful and injected, or if the tension rises, the removal of the lens must be attempted. The operation may be very difficult, especially if the lens lie in the vitreous: it should be performed only in case of necessity, and excision of the globe is often ultimately required.

Concussion cataract is an occasional result of a blow on the eye, not accompanied by a penetrating wound, and not causing dislocation of the lens. The condition has been shown, in some cases at least, to be due to rupture of the posterior part of the lens capsule.

Detachment of the retina may result from hæmorrhage between the retina and the choroid. More frequently it comes on slowly after an interval of some weeks, and is then probably due to shrinkage of the vitreous. The treatment of this condition is very unsatisfactory. Perfect rest in bed for some weeks with both eyes bandaged is sometimes followed by improvement, but this is rarely permanent.

Rupture of the choroid is accompanied by hæmorrhage into the vitreous, and it is only after the vitreous has cleared that the nature of the injury can be recognized by ophthalmoscopic examination. The clefts in the choroid are then seen as white lines over which the retinal vessels pass. They are generally near the optic disc, and arranged concentrically to it. The prognosis as regards useful vision is not good.

Rupture of the Globe is most common in aged people in whom the sclerotic is rigid, and usually results from a severe blow, as with the closed fist. The rupture is most common at the thinnest part of the sclerotic, that is, about four millimetres from the corneal margin. Through the opening any or all of the contents of the globe may escape, and total disorganization of the eye is an almost constant result. Should the conjunctiva remain intact, the lens or iris may escape into the subconjunctival tissue, and the prospect is

slightly more favourable as the interior of the eye is not opened to the air. In the large majority of cases immediate enucleation of the globe is the only treatment. If the rupture be subconjunctival, the case is rather less hopeless, but excision may be required if the eye become shrunken or irritable. If the lens be lying under the conjunctiva, no attempt should be made to remove it until the wound in the sclerotic is firmly healed, and in some cases it causes no discomfort, and may be left to undergo slow absorption.

Penetrating Wounds of the eye-ball are all dangerous to sight, but their severity varies with the size and position of the wound, and the implication of deep structures, and is much increased by the retention of a foreign body and the introduction of septic matter into the interior of the globe. If the wound be large, escape of the contents and hæmorrhage into the eye may render the case scarcely more favourable than one of rupture. A small wound also may be rendered very serious on account of its position. The "dangerous area" is a zone about a quarter of an inch in width behind the corneal margin. This area corresponds to the position of the ciliary body, and wounds of the latter are especially liable to be followed by shrinkage of the globe or by sympathetic ophthalmia. The simplest form of penetrating wound is one in which the cornea only is involved, and which heals without further complication after the escape of the aqueous.

More often the iris becomes entangled in the wound. When such a case is seen within a few hours of the accident and the iris appears to be uninjured, an attempt should be made to replace it with a fine probe. The eye should first be bathed with a weak solution of perchloride of mercury (1 in 3,000), and the previous use of eserine for half an hour will aid reduction by putting traction on the iris and retaining it in position when reduced. If some days have elapsed since the accident no attempt should be made to reduce the prolapsed iris. The latter must then be gently drawn out with fine forceps to free it from its adhesion to the corneal wound and cut off with scissors. Wound of the iris considerably increases the gravity of the injury, for it almost necessarily involves wound of the lens, with resulting swelling and opacity of the latter.

The severity of a penetrating wound may be much increased by the retention of a foreign body in the eye, an accident especially frequent among fitters, riveters, and other workers in metal. Careful examination of the eye should be made as soon as possible after the injury, before the occurrence of iritis or opacity of the lens has perhaps rendered examination difficult. After having carefully examined the iris for a wound, the pupil should be dilated with atropine. The relation of the corneal wound to that in the iris or lens may serve to indicate the direction which the foreign body has taken. The vitreous and the fundus must be successively investigated with the ophthalmoscope. The lower part of the vitreous should be examined with great care, whilst the presence of a retinal hæmorrhage may indicate the position at which the foreign body has struck the back of the globe.

The chemical properties of any substance retained within the eye will in some measure determine the amount of irritation which it causes. Metals are less likely to be tolerated than inert substances, such as glass or stone, whilst an eye containing a fragment of copper has an even worse prospect than one containing a piece of iron of the same size, the salts of the former

being more irritating than those of the latter. Before the introduction of breech-loading guns many eyes were lost from injuries with fragments of copper percussion caps.

The highly albuminous contents of the eye form a very favourable soil for the growth of pyogenic organisms, which have been carried in by a penetrating body or have subsequently gained entrance through the wound. Acute general suppuration (*panophthalmitis*) may follow any penetrating wound of the eye, but occurs most commonly after perforation with some obviously foul instrument, such as a steel dinner fork—a not uncommon accident among children who use a fork to unpick a knotted boot-lace.

The suppurative process extends with great rapidity, appearing first as a yellowish infiltration along the track of the wound, and soon speading into the vitreous. The aqueous becomes turbid, and the wounded cornea may necrose. Iritis is always present, often with hypopyon. If there is an open wound the pus may drain away from it; under other circumstances the sclerotic may give way, to the great relief of the patient. Complete shrinkage of the globe subsequently occurs.

Treatment.—When there is no probability that the eye contains a foreign body, and when the injury is not so severe as to necessitate excision, the wound and the conjunctival sac should be thoroughly cleansed with a weak solution of perchloride of mercury (1 in 3,000), and a compress applied. Atropine should be used twice a day, and leeches applied to the temple if there is pain. If the wound is in the sclerotic, the conjunctiva should be sutured over it, and any protruding vitreous cut off close with scissors. The treatment of prolapsed iris has been described on p. 821. Any case in which the lens is wounded should be carefully watched, lest the swelling of the lens result in glaucoma. The increase of tension will be accompanied by great pain, and often by frequent vomiting. Prompt operation is required in such a case, and should consist in a free incision through the cornea, and the evacuation of the softened lens with a curette.

When a fragment of metal remains imbedded in the cornea or sclerotic, considerable difficulty may be experienced in removing it; if in the sclerotic it is sometimes necessary to enlarge the wound. If the foreign body be adherent to the iris, iridectomy is generally the best treatment, the foreign body being removed together with the damaged portion of iris. A particle of metal lodged in the lens causes less irritation than in any other part of the eye; the lens can sometimes be removed when it has become opaque with the foreign body *in situ*. When the fragment lodges in the vitreous the electro-magnet has been successfully used for its removal, but the case is always very serious and subsequent excision is often required.

Non-penetrating Wounds.—These are of importance only when the cornea is involved, for wounds of the conjunctiva heal readily enough and seldom require the use of sutures unless there is obvious gaping. Corneal wounds assume a special importance from the pain and discomfort which they cause, and from the possibility of local infective processes starting in them. Vision may be impaired by those which encroach on the central region or by those which cause irregularity in the curve of the cornea. The resulting scar tissue may occasion a more or less dense nebula, which may, however, in the case of children, completely disappear in the course of time.

The treatment of these simple corneal wounds consists in bathing the eye

with hot boric lotion, and the use of atropine and cocaine drops. A bandage should be worn until the repair of the wound is complete.

Occasionally a small corneal wound or abrasion becomes infected and takes on an unhealthy action. An ulcer results, which tends to spread on the cornea, first in one direction and then in another (serpiginous ulcer). Pus in the anterior chamber (hypopyon) and iritis are very frequent accompaniments of this form of ulceration. Treatment must be directed to the arrest of the process of ulceration, and this can as a rule be best done by the application of the actual cautery to the spreading margin.

Sympathetic Ophthalmia.—A perforation of one eye by wound or ulceration is occasionally followed by a destructive form of inflammation in the other eye. This so-called "sympathetic ophthalmia" affects primarily the ciliary body and iris, and though often insidious in its onset, tends to cause severe damage or destruction of sight. It is especially likely to follow perforating wounds of the "dangerous area" or those involving the iris (p. 821). The interval which may elapse between the injury of one eye and the onset of inflammation in the other varies greatly, but is probably never less than two weeks. The pathology of sympathetic ophthalmia is doubtful, but the condition probably results from the extension of some specific micro-organism from one eye to the other along the lymph channels of the optic nerves. It is the possibility of its occurrence which gives such a grave importance to the decision whether to preserve or excise a wounded eye; and for the same reason, an eye containing a foreign body can seldom be left with safety. Sympathetic inflammation is sometimes preceded by a condition known as *sympathetic irritation;* the eye is the seat of neuralgic pain, is intolerant of light and tires readily in attempts to read or do near work. Amongst the earliest signs of sympathetic ophthalmia are turbidity of the aqueous with the deposit of fine dots on the posterior surface of the cornea (keratitis punctata); alteration in the colour of the iris and defective action of the pupil; deep injection of the ciliary region of the sclerotic; haziness of the vitreous; and neuro-retinitis. These conditions may be recovered from, but as a rule the inflammation of the iris and other structures progresses until sight is destroyed.

Treatment.—The onset of *sympathetic irritation* is an indication for the immediate excision of the exciting eye. If the signs of *sympathetic ophthalmia* are present the exciting eye, if blind, should be excised, but if it still retains any power of useful vision, this should not be done as this eye may eventually prove the better of the two. In any case excision of the exciting eye seldom has any marked effect upon the inflammation of the sympathising eye; and this in spite of the fact that if done sufficiently early the operation would have altogether prevented it.

The constitutional treatment usually adopted consists in the administration of mercury, which is known to be of undoubted utility in other forms of iritis. Atropine should be used locally, and the application of leeches to the temple relieves the pain. Both eyes should be kept bandaged.

Excision of the Eye-ball.—This is under favourable conditions a simple operation, but some difficulty may be met with if the globe is collapsed, or if the surrounding tissue is adherent from previous inflammation.

The instruments required are a speculum, fixation forceps, strabismus hook, a pair of small blunt-pointed scissors for dividing the conjunctiva and muscles,

and a stronger pair of scissors, curved on the flat, for cutting the optic nerve (Fig. 319).

Having inserted the speculum, the Surgeon picks up the conjunctiva with forceps close to the corneal margin, and often cutting a small opening in it with the scissors, divides it completely round as near the cornea as possible. The capsule of Tenon is next opened by cutting back between the position of any two of the recti muscles, keeping close to the globe. By now passing the strabismus hook along the track of the scissors and sweeping it gently over the surface of the sclerotic, the muscles can be picked up in succession and divided on the hook close to the sclerotic. It is immaterial where the opening in the capsule is made, but a convenient spot is to one side or other of the inferior rectus, and from this opening the operator divides the muscles in whichever

Fig. 319.—*a.* Wire-Speculum. *b.* Toothed Forceps with Fine Points. *c.* Straight Scissors. *d.* Strabismus-Hook. *e.* Scissors for Dividing Optic Nerve in Extirpation of the Eye.

order is most convenient. The optic nerve is next cut through with the curved scissors, which are passed backwards with the blades closed until the optic nerve is felt. Any remaining structures may be divided close to the globe.

A compress should be firmly applied with a bandage for a few hours, after which a light pad of antiseptic gauze or wool is sufficient. At each dressing the lids should be separated and the orbit irrigated with tepid mercurial or boric lotion.

Mouth.—Wounds of the mouth are seldom met with, except as the result of gunshot violence. The amount of injury done to the soft structures, however great, is usually only secondary to the mischief that results to the brain, spinal cord, jaws, and skull, and must of course be dealt with on the ordinary principles of treatment of gunshot and lacerated wounds.

Tongue.—Wounds of the tongue usually occur from its tip or sides being caught between the teeth during an epileptic fit. They have been known to be inflicted by insane patients, in attempts to excise or to bite off this organ. Should the hæmorrhage be free, it can be restrained by the application of a

ligature, or by torsion. The raw surface should then be well dusted with iodoform. These wounds often assume a sloughy appearance for a few days; they then clean up, and granulate healthily. It is useless to bring the edges together by sutures, which readily cut out. If, however, a large portion of the tip be nearly detached, it must be supported in this way; but the sutures, which should be of silkworm-gut or silver wire, must be thick and passed deeply. Pieces of tobacco-pipe are occasionally driven into and broken off in the substance of the tongue, and they either give rise to very free hæmorrhage, or the wound may close and heal over the foreign body, the existence of which may not be known to the patient. In a case of this kind, in which a man complained of much pain and stiffness in the tongue, with difficulty in deglutition, I found a hard swelling towards the base of the organ; on cutting down upon this I extracted three inches of the stem of a clay pipe, which had been lodged there for several months.

THE PALATE and the PHARYNX are sometimes lacerated by gunshot injuries of the mouth; or the wound may result from something that the patient happens to have between his lips being driven forcibly backwards into his mouth. Thus, a tobacco-pipe may, by a blow on the face, be driven deeply into the substance of the tonsil, or perhaps into the pharynx, wounding and lodging behind the arches of the palate; it generally breaks off short, and the fragment that is left in gives rise to an abscess, and perhaps to ulceration of vessels, and fatal secondary hæmorrhage. In a case that was under my care some time ago, the soft palate was nearly detached from the palate bones by a deep transverse wound, caused by the end of a spoon having been forcibly driven into the mouth; good union took place eventually, the parts having been stitched together by a few points of suture. In some rare cases the internal carotid has been wounded from inside the mouth.

CHAPTER XXVII.

INJURIES OF THE THROAT. ASPHYXIA.

INJURIES OF THE LARYNX AND TRACHEA.

Fracture of the Cartilages of the Larynx.—The cartilages of the larynx may be broken and displaced by violent blows or by a squeeze, the fracture in some cases taking place transversely, in others longitudinally. Digital examination will at once detect the nature of the injury. There is superficial extravasation of blood, with pain and difficulty in breathing, speaking, and swallowing. In some cases there is spitting of blood with cough. Fracture of the larynx is an extremely dangerous injury. Durham has collected 69 cases of which 53 died. The great danger is from asphyxia, which may occur immediately as a direct consequence of the displacement due to the fracture, or may come on at a later period as the result of inflammatory swelling. In some cases, simple concussion of the larynx without fracture has been known to prove fatal, apparently from shock. Should symptoms of serious dyspnœa appear, tracheotomy must be performed without delay; if not, attention to position and support of the injured parts will suffice.

Wounds of the Throat.—These are of great frequency and importance, implicating, as they do, some of the most important organs in the body. They may be divided into three categories :—

1. Those that do not extend into the Air- or Food-passages.
2. Those that implicate the Air-passage, with or without injury of the Œsophagus.
3. Those that are accompanied by injury of the Spinal Cord.

These injuries are most commonly suicidal, and may be inflicted with every variety of cutting instrument; except where the spinal cord is injured, which must, in cases of suicide, be the result of gunshot wound, and is necessarily fatal. Though incised, they are often jagged, and partake somewhat of the character of lacerated wounds, with great gaping of the edges.

1. **Wounds not extending into the Air- or Food-passages.**—In these there is very free and even fatal hæmorrhage, and this sometimes though none of the larger arterial or venous trunks have been divided; the blood flowing abundantly from the venous plexuses or from the thyroid body when the wound is low down. If the larger arteries be wounded, as the carotid and its primary branches, the hæmorrhage may be so abundant as to cause almost instantaneous death. Another source of danger in these cases proceeds from the admission of air into the veins of the so-called "dangerous region" of the neck. For this a free wound is by no means necessary, as is proved by a remarkable case that occurred some years ago near London, in which the introduction of a seton into the fore part of the neck was followed by death from this cause.

Wounds of the internal jugular vein are necessarily very dangerous. There is not only the ordinary risk of primary hæmorrhage from a vessel of such large size, but the special danger of the introduction of air into it; should these evils be safely passed, the secondary ones of recurrent hæmorrhage, diffuse inflammation, and pyæmia, may still have to be encountered. Ligature of the vessel above and below the wound in it, exactly as if it were an artery that had been opened, is the only course that can safely be pursued, unless the opening be merely a puncture, when it may be picked up and tied without occluding the lumen of the vessel. In one case, I saw and heard air enter the vein as it was being raised for the passage of the ligature, but the patient made a quick recovery.

The large nerves, such as the vagus and phrenic, can scarcely, in a suicidal wound, be divided without fatal injury to the neighbouring vessels, but they may be injured by stabs or gunshot wounds. The division of the nerves on one side only, or even of one of them, may be fatal in man, by interfering with the proper performance of the respiratory act. In a case with which I am acquainted, in which the phrenic nerve was divided during ligature of the subclavian artery, death resulted in a few days from congestion of the lungs. Sadler has however recorded a case of division of one pneumogastric in a punctured wound in which recovery took place without serious symptoms.

In the **Treatment** of wounds of the neck of this category, the principal points to be attended to are, in the first place, the arrest of hæmorrhage by the ligature of all bleeding vessels, whether arterial or venous; and, secondly, bringing together the lips of the wound. This is best done by the use of sutures and by position. A recent clean-cut wound of the throat of this class may as a rule be safely closed with sutures, and thus primary union obtained. If the wound is transverse, the head should be fixed, with the chin almost touching the sternum, and retained in this posture by tapes passing from a nightcap to a piece of bandage fixed round the chest. I have had under my care one case in which, owing to the projection and mobility of the larynx, the wound did not unite, a large and deep gap being left, which required a series of plastic operations in order to effect its closure.

2. **Wounds implicating the Air-passage.**—Wound of the air-passage is common, and is revealed in suicidal attempts by the air being heard and seen to bubble in and out of the wound during respiration. These wounds vary much in extent, from a small puncture with the point of a penknife to a cut extending completely across the throat, and even notching the vertebræ. They are frequently complicated with injuries of the larger vessels and nerves, and sometimes with wound of the œsophagus. Most commonly the cut is made high up in the neck; for the suicide, thinking that it is the opening into the air-passage that destroys life, draws the razor across that part of the throat where this is most prominent and easily reached; and thus, through not wounding the larger vessels, which are saved by the projection of the larynx, he frequently fails in accomplishing his object.

These wounds occur in four situations: above the Hyoid Bone; in the Thyro-hyoid Space; through the Larynx; and through the Trachea.

The wound may be made **above the Hyoid Bone**, the cut extending into the mouth and wounding the root of the tongue. A wound in this situation is usually attended with much hæmorrhage; and there is great trouble in feeding the patient, as the power of swallowing is completely lost.

The wound may be inflicted in the **Thyro-hyoid Space,** laying the pharynx open, but being altogether above the larynx. This is the most common situation for suicidal attempts. In many cases, the incision is carried so low as to shave off or partly detach the epiglottis and the folds of mucous membrane around it. In other cases, the edges of the glottis or the arytænoid cartilages are injured, the cut extending back to the bodies of the vertebræ. Here also there is great difficulty in swallowing and great risk of the sudden supervention of œdema of the glottis, and consequent suffocation.

When the **Larynx** is wounded the incision is usually transverse ; but I have seen a longitudinal cut made through the larynx, splitting the thyroid and cricoid cartilages perpendicularly. In these cases of wounded larynx, there is great danger of the blood from the superficial parts trickling into the air-passage and asphyxiating the patient, and of inflammation of the bronchi and lungs supervening at a later period.

Wounds of the **Trachea** are not so common as those of the larynx, from which they differ but little in the attendant dangers.

The **Œsophagus** is seldom wounded, and such wounds still more rarely come under the care of the Surgeon, as the part can be reached only through the trachea by a deep cut, which will probably implicate the large vessels. The œsophagus has also been wounded from within in performing the feat of "sword-swallowing."

Effects.—There are various sources of danger in wounds of the neck implicating the air-passage. The *hæmorrhage*, whether it proceed from any of the larger trunks, or consist of general oozing from a vascular surface, may prove fatal either directly by the amount of blood lost, or indirectly in consequence of the blood trickling into the air-tube, and producing suffocation.

Asphyxia may supervene, either in the way already mentioned, or, when the wound has been inflicted above the larynx, from the occurrence of œdema of the glottis. It may likewise occur when the external opening is very small, and occasionally happens suddenly when the wound is nearly closed.

Another source of danger is the *loss of the natural sensibility of the glottis*, in consequence of which it no longer contracts on the application of a stimulus. Hence food taken in by the mouth may pass into the larynx and appear at the external wound, though neither the pharynx nor the œsophagus has been wounded. This I have observed in many cases of cut throat ; hence the presence of food in the wound cannot in all cases be considered an evidence of injury to the food passage. In some cases this may be due to wound of the superior laryngeal nerve, but it quite as frequently occurs in cases in which it is certain that this nerve is uninjured. It is then a bad sign, and is never met with until a semi-asphyxial condition has come on, by which nervous irritability is blunted, or until inflammation has been set up about the rima glottidis, giving rise to so much swelling as to interfere with the natural action of the muscles, and to deaden the perception of the part to the contact of a foreign body. In these cases also the sensibility of the air-passage generally is much lowered, so that mucus accumulates in the bronchi, even to a dangerous extent, the patient not feeling the necessity for expectoration, and often, indeed, having much difficulty in emptying his chest; his efforts at clearing the bronchi being reduced to a forced expiration, as a true cough is impossible while the wound is open below the glottis.

The occurrence of *bronchitis* and *septic broncho-pneumonia* is a frequent

cause of death in patients who survive the immediate effects of the wound. This is due in many cases partly to the direct admission of cold air, without its being warmed by passing through the nasal cavities, but much more often it results from the inhalation of the septic discharges from the wound. At the *post-mortem* examination of these cases the bronchi are found intensely injected; the lungs are as a rule swollen and œdematous throughout, and here and there patches of consolidation will be felt. On cutting into these they will be breaking down and softening in the centre, sometimes forming cavities almost like abscesses. They differ, however, from the secondary abscesses of pyæmia in being scattered through the lung and not specially on the surface; and if a patch be found in an early stage, it will be seen that there is no hæmorrhagic infarct preceding the softening, but that the air-vesicles are distended with opaque puriform secretion, and that the cavities are formed by the coalescence of the distended air-vesicles through destruction of their walls. The pathology of the process seems to be that septic matter from the wound is inhaled and lodges in the smaller bronchi where it sets up acute purulent catarrh with decomposition of the secretions. The decomposing secretions excite inflammation terminating in gangrene of the surrounding tissue of the lung. In some cases extensive areas of the lung may thus become gangrenous.

The *depressed mental condition* of the patient also is usually unfavourable to recovery when the wound is suicidal.

Treatment.—The same general principles apply as in the management of those wounds of the throat that do not open up the mucous canals in this region. Hæmorrhage must be arrested by ligature of all the bleeding vessels, whether arteries or veins, so that no oozing or trickling into the wound may take place. In some cases the hæmorrhage consists principally of general venous oozing which cannot be stopped by ligature, the patient drawing a large quantity of blood into the air-passage through the wound. In these circumstances I have found it useful to introduce a large silver tube into the aperture in the windpipe, and to plug the wound around it. As soon as the bleeding has fairly ceased, the plugs and the tube must be removed.

It has long been a recognized rule not to close wounds of the throat of this category with sutures, except, perhaps, at the angles. In this way the risks of an accumulation of coagula in the wound, and more especially the burrowing of septic matter between the deep cervical fascia, are effectually prevented. With improved methods of the treatment of wounds this rule cannot now be considered an absolute one. Morris, Pollard, and others have recorded cases which show that with efficient antiseptic precautions even an extensive wound of the throat may be accurately closed with sutures, and thus primary union obtained. The wound in the air-tube must first be carefully united with fine silk sutures, and it may be advisable to bring together the divided muscles and fascia with buried sutures before finally closing the skin wound. Provision for drainage will usually be required. This mode of treatment is, however, justified only when the Surgeon is able to carry out all the details of the antiseptic method; under other circumstances, the rule of leaving the wound widely open should be followed. If the trachea has been completely cut across it is always advisable to insert a stitch in each side of the tube, in order to prevent the wide separation of the two portions that would otherwise take place, owing to the great mobility of the larynx and upper end of the

windpipe. The head must be kept in a flexed position by the use of tapes, as described on p. 827.

In order to lessen the liability to inflammation of the lungs, the patient should be put into a room, the temperature of which is raised to about 70° Fahr. A piece of lightly folded gauze, acting as a filter, should be laid over the wound if this has been left open, and as soon as the cut surfaces begin to granulate, the edges of the wound may be brought into apposition by strips of plaster, and a compress if necessary. During the treatment, the principal danger proceeds from inflammatory affections of the chest; these must accordingly be counteracted by the temperature in which the patient is placed, and by making every effort to prevent as far as possible the accumulation of decomposing discharges about the wound, for which purpose iodoform is most useful. It must be remembered that the mental depression, and the bodily exhaustion from loss of blood, that are common in these cases, do not allow of any lowering treatment.

The **administration of food** always requires much attention. As a general rule, the patient should be kept on a nourishing diet, with a moderate allowance of stimulants. If, as not uncommonly happens, the food-passage be opened in consequence of the wound extending into the mouth, the pharynx, or the œsophagus, it is of course impossible for the patient to swallow, and the administration of nourishment becomes very difficult. It is best accomplished by means of a gum-elastic catheter passed through the mouth into the gullet or stomach. This is easier than passing the instrument through the nose, and much better than introducing it through the wound. In this way a pint or more of the strongest beef-tea or soup, mixed with two or three eggs, and having an ounce or two of brandy added to it, should be injected regularly night and morning, until the patient is able to swallow. In those cases in which the wound is above the larynx, there is occasional danger of the supervention of œdema of the glottis; should this occur, tracheotomy may be necessary.

As consequences of wounds of the throat, we occasionally find stricture of the trachea, or aërial fistula. If the vocal cords have been injured, loss of voice may follow.

Aërial Fistula may sometimes form owing to the skin doubling in and becoming adherent to the edges of the wound in the air-tube, and most frequently occurs when the cut is in the thyro-hyoid space; adhesion taking place between the inverted integuments and the os hyoides above, and the surface of the thyroid cartilage below. The same may occur in the crico-thyroid space, and indeed at any part of the larynx that has been opened. When this happens, the fistula tends to remain patent. In these circumstances, I have found the following operation successful.

The edges of the fistulous opening having been freely pared, and the knife passed under them for some distance, so as to detach them from the subjacent parts, a vertical incision is made through the lower lip of the opening, so as to split it downwards. Two points of suture are then inserted into each side of the horizontal incisions, bringing their edges into contact, *but the vertical cut is left free* for discharges and mucus to drain through, and for the expired air to escape, lest emphysema occur. Unless this outlet be afforded, the fluids will burst through the sutures, and thus destroy union of the edges.

It is not in every case that an aërial fistula can safely be closed. In some instances the larynx becomes contracted either by drawing in of the wound, or by thickening of the mucous membrane above the artificial opening to such an extent that the fistula becomes essential, for the purposes of respiration. In such circumstances, any attempt at closing it will be followed by symptoms of impending asphyxia ; and it may be necessary to leave the opening free, or even, as happened in a case under my care, in which an opening was left in the crico-thyroid membrane of a girl who had attempted suicide by cutting her throat, to enlarge the opening and introduce a silver tube. Intubation of the larynx (see Chap. LVIII.) is a mode of treatment which should be given a trial in such cases.

FOREIGN BODIES IN THE AIR-PASSAGE.—A great variety of substances have been found in the air-passage : such as nut-shells, beans, cherry-stones, teeth, meat, money, buttons, pins, fish-bones, bullets, pills, pebbles, and pieces of wood. These foreign bodies are not introduced into the air-passage by any effort of deglutition, for no substance can be *swallowed* through the glottis. They are *inhaled;* thus, if a person, whilst holding anything in his mouth, make a sudden inspiration, the current of air may draw it between the lips of the dilated glottis into the larynx.

The symptoms vary, according to the situation in which the foreign body is lodged, its nature, and the time that has elapsed since the occurrence of the accident. The foreign body may lodge in one of the ventricles of the larynx ; if light, it may remain in the trachea, and be carried up and down by the movement of the air in expiration and inspiration ; if too heavy for this, it will fall into one or other of the primary divisions of the trachea, and, as Aston Key has observed, will most commonly be found in the right bronchus. The explanation of this has been pointed out by Gray, who states that on making a transverse section of the trachea, and taking a bird's-eye view of the bifurcation, the septum will be seen to be considerably to the left of the middle line ; and further it has been shewn by Aeby that the right bronchus is in a more direct line with the trachea than the left. The greater size of the right bronchus would also favour the entrance of a foreign body into it. If the substance be small, it may pass into one of the secondary divisions of the bronchi ; and, if it continue lodged here for a sufficient length of time, it may make a kind of cavity for itself in the substance of the lung, where it may either excite suppuration round it or become encysted.

The *Symptoms* may be divided into three stages : 1. Obstruction, immediately following the introduction of the substance; 2. Irritation, produced by its presence ; and 3. Inflammation, coming on at a later period.

1. **Symptoms of Obstruction.**—The immediate symptoms vary somewhat according to the size and nature of the foreign body, and the part of the air-tube that it reaches. In all cases there is a feeling of intense suffocation, with great difficulty of breathing, and violent fits of spasmodic coughing, often attended by vomiting, during which the foreign body may be expelled. Indeed, its partial entry and immediate extrusion by coughing are not uncommon. In some cases immediate death may ensue at this period from obstruction of the glottis. If the body have entered the air-passage fully, there is violent coughing, with a feeling of suffocation for an hour or two, accompanied by lividity of the face, great anxiety, and a sense of impending death. There is

also usually pain about the episternal notch. The symptoms then gradually subside, but any movement on the part of the patient brings them on again with renewed violence. All these symptoms are most severe if the foreign body remain in the larynx; the voice being then croupy, irregular in tone, or altogether lost. If it be lodged elsewhere, as often as it is coughed up and strikes against the interior of the larynx, an intense feeling of suffocation is produced; and if it happen to become impacted there, sudden death may result, even though it be not of sufficient size to block up the air-passage, apparently by the spasm that is induced. Many years ago I saw a boy die before tracheotomy could be performed, in consequence of a flat piece of walnut-shell that had entered the trachea being suddenly coughed up, and becoming impacted in one of the ventricles of the larynx. The symptoms, during this period, are much less severe when the foreign body is in the trachea or bronchi.

When there is a suspicion that the foreign body is lodged in the larynx, a laryngoscopic examination should be made, when it may, perhaps, if large—as a plate with false teeth—be seen between the vocal cords. Small bodies also have several times been detected in this way lodging in one of the ventricles of the larynx.

2. **Symptoms of Irritation.**—When the foreign body has passed into the air-passage, and the immediate effects produced by its introduction have subsided, another set of symptoms, dependent on the irritation produced by it, is met with; and it is during the occurrence of these that the patient is most generally brought under the Surgeon's observation.

The **General Symptoms** consist of occasional fits of spasmodic cough accompanied by much difficulty of breathing, a feeling of suffocation, and an appearance of urgent distress in the countenance. These attacks do not occur when the patient is tranquil, but come on whenever the foreign body is coughed up so as to strike the larynx, and the upper and more sensitive parts of the air-passage. In children the spasmodic cough caused by the presence in the air-passages of a small irritating body, such as a blade of grass, has been mistaken for whooping cough. As a general rule, the distress is less the lower the substance is lodged; the sensibility of the lower portion of the trachea and that of the bronchi being much less acute than that of the larynx and of the upper part of the trachea. In consequence of the irritation, there is usually abundant expectoration of frothy mucus. These symptoms often remit for a time, more particularly if the foreign body become fixed. In some cases, indeed, there appears to be so little distress some days after the accident, that considerable doubt may exist whether any foreign body really be lodged in the air-passage or in the lungs; and much valuable time is often lost by the indisposition of the Surgeon to adopt active measures.

The **Physical Signs** depend necessarily upon the situation of the foreign body. If this be loose and floating, it may be heard, on applying the ear to the chest, moving up and down, and occasionally striking against the side of the trachea. If it be fixed, it will necessarily give rise to a certain degree of obstruction to the admission of the air beyond it, perhaps occasioning sibilant or sonorous rhonchi during either inspiration or expiration or both. If it be impacted in the larynx, the voice will be hoarse and croupy, and there will be a loud rough sound in respiration, with much spasmodic cough and distress in breathing. If the foreign body be impacted in one bronchus, the physical

signs will vary according to circumstances. If it be angular or perforated a peculiar whistling noise may be heard as the air passes over or through it. A piece of broken tracheotomy tube has been known to become impacted in one bronchus without the production of any abnormal physical signs, the position of the foreign body being unsuspected until the occurrence of signs of inflammation in the affected lung. If the foreign body completely obstructs the bronchus, the respiratory murmur will be wanting on the side on which it is lodged. As a rule the obstruction is somewhat valvular in character, allowing a little air to be forced out during expiration but none to enter in inspiration, and extreme collapse of the affected lung may thus arise. There will then be absolute dulness on percussion, with deficiency on measurement and a want of expansion during inspiration. In other cases in which the form of the foreign body is such as not to obstruct the bronchus, the physical signs will be much less marked. If one of the subdivisions of either bronchus be occupied by the foreign body, the entrance of air will be prevented in the corresponding lobe of that lung, though it enter freely every other part of the chest.

3. **Inflammation.**—After a foreign body has been lodged for a day or two, *inflammation of the bronchi or lungs* is apt to be set up ; in some cases, however, this occurs only after a considerable time has elapsed, or, perhaps, not at all—much depending, of course, on the shape and character of the irritant. In some cases an acute destructive inflammation of the lung occurs and proves fatal in a few weeks. If the foreign body completely obstruct one bronchus, the corresponding lung gradually becomes collapsed ; and after a time abscesses form in it, apparently in consequence of the retention of the natural secretion in the smaller bronchi and air-vesicles. This condition of bronchiectasis usually proves fatal eventually either by the supervention of albumenoid disease or of acute inflammation of the lung. Godlee points out that unilateral bronchiectasis in a child is suggestive of the presence of a foreign body. In some cases a cavity forms in the substance of the lung around the foreign body, whence purulent matter is continually expectorated. Death in such cases may result after many months, or a year or two, from tuberculous phthisis. In very rare cases a foreign body has spontaneously escaped from the lung through an abscess pointing in the chest wall.

Should any of the above-mentioned changes have occurred in the lung, the expulsion of the foreign body is by no means necessarily followed by a cure.

Prognosis.—This depends more upon the nature of the foreign body and its size than on any other circumstance. If it be rough, angular, and hard, there is necessarily much more risk than if it be soluble in, or capable of disintegration by, the mucus of the air-passage. So long as the foreign body is allowed to remain, the patient is in imminent danger, either from immediate and sudden suffocation, or from inflammation at a more remote period.

The danger depends greatly upon the length of time during which the body is allowed to lodge. Of 62 cases which I collected in 1850 (4 of which had fallen under my own observation), I found the time that the foreign body was allowed to remain in, and the result of the case, stated in 49 instances.

PERIOD OF RETENTION.	NUMBER OF CASES.	RE-COVERED.	DIED.
Less than 24 hours	8	6	2
Between 24 and 48 hours	4	3	1
Between 48 hours and 1 week	13	6	7
Between 1 week and 1 month	8	4	4
Between 1 month and 3 months	3	3	0
Between 3 months and 1 year	6	4	2
More than 1 year	7	4	3
Total	49	30	19

From this it would appear that, if the patient escaped the danger of the immediate introduction, the greatest risk occurred between the second day and the end of the first month, no fewer than 11 patients out of 21 dying during this period ; and then that the mortality diminished until the third month, from which time it again increased.

The cause of death varies also according to the period at which the fatal result takes place. During the first twenty-four, and, indeed, forty-eight hours, it takes place from sudden asphyxia and convulsions. During the first few weeks it is apt to occur from inflammatory mischief within the chest ; and after some months the patient will be carried off by the gradual exhaustion consequent upon the formation of abscesses in the lung.

Spontaneous expulsion of the foreign body occasionally occurs, usually in a violent fit of coughing. Gross of Philadelphia found that there are 49 cases on record, in which the body was spontaneously expelled, the patient recovering. In 37 of these, it was expelled during a fit of coughing. The period during which a foreign substance may remain in the air-passage before it is spontaneously expelled varies from a few minutes to many months or years ; in one case a piece of bone, introduced at the age of three, was not ejected until sixty years had elapsed. Tulpius relates a case in which a nut-shell was coughed up after being lodged for seven years ; and Heister one in which a ducat was thus brought up after a lapse of two years and a half ; the patients, in both instances, recovering. In other cases death may ensue, although the foreign body is coughed up ; thus Sue relates an instance in which a pigeon-bone was spat up seventeen years after its introduction, the patient, however, dying in little more than a year from marasmus. In eight of the cases collected by Gross, death followed the spontaneous expulsion.

Treatment.—This accident is always very serious, and hence requires the use of prompt and energetic means in order to save the patient ; and fortunately the means at our disposal, consisting of the simple operation of opening the trachea and thus facilitating the expulsion of a foreign body, are usually highly successful. Of 60 cases in which the result was noted, I found that 37 lived, and 23 died ; but on analysing these cases more closely, it appeared that in 39 no operation was performed, the expulsion of the foreign body being effected by the efforts of nature. Of these 23 died, and 16 lived. In the remaining 21 cases, tabulated below, tracheotomy was performed ; of these 18 lived, and only 3 died, showing a remarkable success attendant on this operation.

PERIOD OF RETENTION.	NUMBER OF CASES.	CURED.	DIED.
Less than 24 hours	3	2	1
Between 24 and 48 hours.	2	2	0
Between 48 hours and 1 week	9	8	1
Between 1 week and 1 month	5	4	1
Between 1 month and 3 months	2	2	0
Total	21	18	3

The statistics as to the result of operations for the removal of foreign bodies from the air-passages have been worked out chiefly by Gross, Durham, and West (U. S. A.). Gross has collected the particulars of 85 cases not operated on. Of these 56 recovered and 29 died, the deaths amounting to 34·11 per cent. Tracheotomy was done in 98 cases: of these 83 recovered and 15, or 15·30 per cent., died. Durham collected 271 cases not operated on. Of these 156 recovered and 115, or 42·2 per cent., died; whilst of 283 cases operated on, 213 recovered and 70, or 24·2 per cent., died. West (U. S. A.) has collected 1000 cases. Of these, in 63 cases the foreign body was removed by forceps, with or without the aid of the laryngoscope. Of the remaining 937 cases, 599 were not operated on. Of these 460 recovered and 139, or 23·20 per cent., died. In 398 cases the air-passages were opened. Of these 245 recovered and 93, or 27·42 per cent., died.

Taking the combined results of these three tables and comparing them in reference to the particular operation performed, we find that the results are as follows: of laryngotomy there were 70 cases, in all of which probably the foreign body was impacted in the glottis, with 56 recoveries and 14, or 20 per cent., of deaths; laryngo-tracheotomy, 59 cases, with 44 recoveries and 15, or 25·42 per cent., deaths; tracheotomy was performed in 605 cases, with 449 recoveries and 156, or 25·78 per cent., deaths.

The Surgeon may be hurriedly summoned to a patient, probably a child, who has "swallowed" a foreign body and is *in extremis* from asphyxia. Under these circumstances he should pass his finger to the back of the throat, where the foreign body may be felt and possibly extracted by using the index fingers of the two hands. Failing this, *laryngotomy* should at once be performed. Every moment is of consequence, and the Surgeon who is probably single-handed, and possibly provided with no instruments beyond a penknife, is little prepared for the far more troublesome operation of tracheotomy.

In the treatment of less urgent cases, emetics, sternutatories, and succussion of the body, are all either useless or dangerous. Inversion of the body has succeeded in several instances, and might be tried before operation is had recourse to, more particularly if the foreign body is heavy, as a coin, and is movable in the air-passage. Padley caused the ejection of a sixpenny-piece in this way from the trachea of a man, and he recommends the supine as a safer and better position than the prone. There is undoubtedly danger, in inversion, of the supervention of laryngeal spasm, but statistics do not prove that any fatal consequences have resulted from this cause. Should, however, the attempt at expulsion by inversion of the body bring on an attack of laryngeal spasm, it should be abandoned, as not only useless but in the highest degree dangerous.

When *the foreign body is lodged in the larynx*, it can be detected by laryngo-

scopic examination, and may be removed with forceps or by such other means as the ingenuity of the Surgeon may suggest. This may sometimes be done a considerable length of time after its impaction. Thus in a case recorded by Petrie of Liverpool, a coin was successfully removed with forceps after having been impacted six years in the larynx of a boy.

Should it, however, not be possible to extract the foreign body through the mouth, tracheotomy must be performed, and an attempt made to dislodge it from below by means of a feather passed up into the mouth, or it may possibly be seized and brought out by the wound. Should this fail, the operation of **Thyro-chondrotomy**, more often, but incorrectly, called **Thyrotomy**, should be performed. The operation is the same as that for intralaryngeal tumours, and will be described in the Chapter on Diseases of the Throat. It is of importance that it should not be delayed, for the foreign body, more especially if rough or irregular, as a piece of bone, will shortly excite inflammation and ulceration of the mucous membrane and possibly entail permanent impairment of voice or of respiration.

When *the foreign body has passed beyond the larynx*, or is not to be recognised by means of the laryngoscope, inversion may perhaps be tried in some cases, but, as a rule, tracheotomy ought to be performed at once. Tracheotomy is in all cases preferable to laryngotomy, as the opening can be made more freely and left open more easily, and moreover, being further removed from the glottis there is no possibility of both openings being blocked by the foreign body if it be coughed up. The operation should be performed even though the symptoms be not urgent. There is often a remission in the symptoms, a period of deceptive security, by which the Surgeon must not be put off his guard. But, it may be asked, for what purpose is the trachea opened? Why should not the foreign body be expelled through the same aperture by which it has entered? The opening in the trachea serves a double purpose; it not only affords a ready and passive outlet for the expulsion of the foreign body, but serves as a second breathing aperture in the event of its escaping through the glottis. The advantage of the opening in the trachea as a ready aperture of expulsion is evident from the statistics given by Durham of 212 cases in which tracheotomy was performed for a foreign body in the air-passages. One hundred and fifty-seven recovered: in 64 of these spontaneous expulsion took place through the tracheal opening: in 35 spontaneous expulsion occurred from the mouth, and in 58 the foreign body was removed with forceps or other instruments. Fifty-five died: in 48 of these the body was retained till death, in 2 it was expelled from the mouth, and in 2 from the wound immediately after the operation, and in 3 it was removed with forceps.

The reason why the foreign body usually passes out of the artificial opening instead of escaping by the glottis, is, that the sides of the former aperture are passive, whereas those of the latter are highly sensitive and contractile. Before the operation is performed, it will be found that the great obstacle to expulsion is the spasmodic contraction of the glottis, by the closure of which not only is the passage of the foreign body prevented, but respiration is impeded. Every time the foreign body is coughed up so as to touch the interior of the larynx, intense dyspnœa is produced, owing to sudden and involuntary closure of the glottis, by which respiration is entirely prevented and suffocation threatened; the expulsion of the body is consequently

arrested, unless it by chance take the glottis by surprise, and pass through it at once in the same way that it has entered it, without touching its sides. If it be arrested by the spasm in the glottis it is inevitably drawn down into the trachea again by the deep inspiration that follows the relaxation of the spasm. If there be a second breathing aperture, though the larynx is equally irritated by the foreign body, yet this dyspnœa cannot occur, respiration being carried on uninterruptedly by one opening whilst the foreign body escapes through the other; and thus, in these circumstances, it may pass through the glottis with but little inconvenience. In performing tracheotomy for a foreign body in the air passages, the opening must be made freely; no tube must be introduced, but the edges of the wound must be kept open by blunt hooks, made of bent wire, and secured behind the neck by a piece of tape.

In some cases, the foreign body is expelled at once after the trachea has been opened; in others, not until some hours, days, or even weeks, have elapsed. Thus, in Houston's case, a piece of stick was not coughed up until ninety-seven days after the operation; and in Brodie's case, in which the celebrated engineer, Brunel, was the patient, sixteen days elapsed before the half-sovereign came away.

The expulsion has in some instances been facilitated by inverting the patient, shaking him, or striking him on the back. In cases in which the foreign body has not readily been expelled, forceps and other instruments have been introduced through the wound to extract it. But, although in many instances this has succeeded, these proceedings should not be lightly undertaken. It is better always to wait some time, as in a large number of successful cases expulsion has not taken place spontaneously till more than twenty-four hours after the operation. If the body does not come up spontaneously by the end of the second day, the Surgeon is not justified in further delay, as the mischief set up in the lung may soon become irreparable. The patient must be put fully under an anæsthetic, and even then the introduction of the instrument will cause a violent spasmodic cough. If the nature of the foreign body be known, the instrument must be adapted to it. If it be of metal, glass, or china, its position can first be detected by means of a probe. If it be of the form most easily to be seized with forceps, Gross's tracheal forceps, or Durham's flexible forceps may be used. It is difficult, however, in using forceps to avoid passing the blades down two separate bronchial tubes and thus seizing the septum between them. A loop of stiff wire, bent at its extremity to an angle so that it can be directed into either bronchus, will be found very useful in dislodging a round body impacted in a bronchus. In this way a plum-stone was easily dislodged and removed in a case which occurred in University College Hospital some years ago, and the child rapidly recovered. During these operations the opening in the trachea may be kept open, as suggested by Thomas Smith, by temporarily suturing together the edges of the tracheal and skin incisions. Should the attempt fail, the wound should be kept open by means of blunt hooks for a week or ten days longer, when perhaps the foreign body may be ejected. After its escape, the opening in the trachea must be allowed to close.

Scalds of the Mouth, the Pharynx, and the Glottis, occasionally occur from attempts to swallow boiling water; or these parts are scorched by the inhalation of hot air or flame. The scalding happens chiefly to the

children of the poor, who, being in the habit of drinking cold water from the spout of a kettle, inadvertently attempt to take a draught from the same source when the water is boiling. The hot liquor is not swallowed, but, though immediately ejected, it scalds the inside of the mouth and pharynx, giving rise to great inflammation, which, extending to the glottis, will produce œdema of it, and thus speedily destroy life by suffocation. In three cases which I examined after death, there was no sign of inflammation below the glottis, though the lips of this aperture were greatly swollen; and this I believe to be invariably the case. The accident always reveals itself by very evident signs; the interior of the mouth looks white and scalded, the child complains of great pain, and difficulty of breathing soon sets in, expiration being comparatively easy, while inspiration is obstructed by the swollen arytæno-epiglottidean folds falling together over the glottis in a valve-like manner. This condition, unless efficiently relieved, may terminate in speedy suffocation. In those cases in which these parts have been similarly injured by the flame produced by the explosion of gas or of fire-damp being sucked into the mouth, the same conditions present themselves.

In the **Treatment** of this injury, the main point to attend to is to subdue the inflammation before it involves the glottis to a dangerous extent. With this view, leeches should be freely applied to the neck, and hot fomentations put on. If symptoms of dyspnœa have set in, the œdematous parts should be freely scarified with a curved bistoury, sheathed by wrapping adhesive plaster round it nearly to its point. If this be not at hand, much may be done by means of the finger nail, notched so that it may tear the mucous membrane. The child should be placed in a tent-bed, and the steam-spray used. Should these measures fail to give relief, intubation or tracheotomy must be performed without delay. Intubation is likely to be attended with some difficulty, owing to the swollen condition of the part, so that the Surgeon who is not skilled in this procedure had better resort at once to tracheotomy. A tube must be inserted and retained until the swelling about the glottis has subsided. In the majority of the cases, however, that have fallen under my observation, in which this operation has been performed, the issue has been a fatal one, from the speedy supervention of broncho-pneumonia. Bernard Pitts has collected seventy-eight cases of this injury, treated in St. Thomas's Hospital. Of these sixty-three recovered—seven after tracheotomy, one after intubation followed by tracheotomy, and three after intubation alone. In twelve of the fifteen fatal cases tracheotomy was performed, the operation having been preceded by intubation in three.

ASPHYXIA.

Asphyxia may arise from various causes. The following classification is derived from a table by Harley :—

I. **Mechanical Impediment to the Entrance of Air into the Lungs.** A. From **Accident**: either (1) *external*, as in pressure on the trunk preventing expansion of the chest; pressure on the throat; smothering; injury of the spinal cord causing paralysis of the respiratory muscles; penetrating wound of the chest, admitting air; or (2) *internal*, as in obstruction of the fauces or larynx by foreign bodies, or in constriction of these parts from the application of irritating fluids. B. From **Disease**; as in pressure on the

trachea by an aneurism or other tumour; œdema of the glottis; obstruction of the air-passage by tumour; accumulated mucus, &c.

2. **Drowning.**

3. **Absence of Oxygen,**—nitrogen, hydrogen, or some other harmless gas being inhaled.

4. **Accumulation of Carbonic Acid Gas in the Blood.**

5. **Inhalation of Toxic Gas or Vapour.**

Several of the conditions above enumerated as producing asphyxia have been described in the preceding pages; and others will be considered when we speak of diseases of, and operations on, the Air-passage. In this place we will speak of the Surgical management of cases in which respiration has been suspended by Drowning, Hanging, and the respiration of Noxious Gases.

The general subject of Suspended Animation from these various causes cannot be discussed here, but we must briefly consider some points of practical importance in its treatment.

In cases of **Drowning**, life can often be restored, although the sufferer may have been in the water for a considerable time; for, though *immersed*, he may very probably not have been *submersed* during the whole time. The period after which life ceases to be recoverable cannot be very accurately estimated. The officers of the Royal Humane Society, who have great experience, state that generally persons are not recoverable who have been more than four or five minutes under water. In these cases, however, although submersion may not continue for a longer period than this, the process of asphyxia does; for it does not cease on the withdrawal of the body from the water, but continues until the blood in the pulmonary vessels is aërated, either by the spontaneous or artificial inflation of the lungs. As several minutes are commonly consumed in withdrawing the body from the water and conveying it to land, during which time no means can be taken to introduce air into the lungs, we must regard the asphyxia as continuing during the whole of the period that intervenes between the last inspiration before complete submersion, and the first inspiration, whether artificial or spontaneous, after the removal of the body from the water. The latest time at which life can be recalled, during this period, is the measure of the duration of life in asphyxia. If, during this period, the action of the heart should cease entirely, I believe that the circulation can never be restored. But although we may put out of consideration those marvellous cases of restoration of life that are recorded by the older writers, and which are evidently unworthy of belief, are we to reject, as apocryphal, cases such as that related by Smethurst, in which recovery took place after ten minutes' submersion; that by Douglas of Havre, in which the patient was not only submersed, but had actually sunk into, and was fixed in the mud at the bottom of the harbour for from twelve to fourteen minutes; or that by Weeks, in which the submersion, on the testimony of the most credible witnesses, exceeded half an hour? I think that it would be unphilosophical in the extreme to deny the facts clearly stated by these observers; the more so that in these, as in many other instances of apparent death from drowning, life appears to have been prolonged by the patient falling into a state of syncope at the moment of immersion. We must therefore not despair of recovery, but should employ means of resuscitation, even though the body have been actually under water a considerable time.

There are certain minor means often employed in the case of persons who

have been immersed in water, and are apparently drowned, which appear to be well adapted for the treatment of the less severe forms of asphyxia, or rather cases of syncope from fright and immersion in cold water. These consist, after the nose and mouth have been cleared of mucus, in the application of heat by means of a bath at about the temperature of 100° Fahr. until the natural warmth is restored; in the employment of brisk friction; and in passing ammonia to and fro under the nostrils. It is evident that these measures can have no direct influence upon the heart and lungs, but can only act as general stimuli to the system, equalizing the circulation if it be still going on; and, by determining the flow of blood to the surface, tending to remove those congestions that are the consequences not so much of the asphyxia as of the sojourn of the body for several minutes in cold water; they would therefore be of especial service during the colder seasons of the year. A hot bath may also, by the shock it gives, excite the reflex respiratory movements. With the view of doing this with a greater degree of certainty, cold water should be sprinkled or dashed upon the face at the time when the body is immersed in the hot bath, as in this way a most powerful exciting influence can be communicated to the respiratory muscles, and the first object of treatment in all cases of axphyxia—the re-establishment of respiration—would more rapidly and effectually be accomplished; deep gaspings ensuing, by which the air would be sucked into the remote ramifications of the air-cells, aërating the blood that had accumulated in the pulmonary vessels, and enabling it to find its way to the left cavities of the heart, and thus to excite that organ to increased activity. These means, then, are useful in those cases of asphyxia in which the sufferer has been but a short time submersed, and in which the heart is still acting and the respiratory movements have either begun of their own accord on the patient being removed from the water, or in which they are capable of being excited by the shock of a hot bath, aided by the dashing of cold water on the face. At the same time the lungs may be filled with pure air, by compressing the chest and abdomen, so as to expel the vitiated air, and then allowing them to recover their usual dimensions by the natural resiliency of their parietes. A small quantity of air will, in this way, be sucked in each time the chest is allowed to expand, and thus the re-establishment of the natural process of respiration may be greatly hastened. This simple mode of restoring the vital actions should never be omitted, as it is not attended with the least danger, and does not in any way interfere with the other measures employed. Marshall Hall has recommended that the patient be turned prone, so that the tongue may hang forwards, and the larynx thus be opened; and that respiration be then set up by gentle pressure along the back, and by turning the patient on his side at regular intervals. This position is very valuable in draining away the water from the bronchial tubes, which is very necessary in cases of drowning before any attempt is made to introduce air into the lungs. If, by these means, we succeed in rapidly restoring the proper action of the respiratory movements, it will be necessary merely to pay attention to the after-treatment. Should we, however, fail in restoring respiration, we should have recourse to other and more active measures.

In the more severe cases of asphyxia, the most direct and efficient means that we possess for the re-establishment of the circulation is **Artificial Respiration**, which should be resorted to without delay. The whole value of artificial respiration, however, depends upon the way in which it is

employed. Inflation from the mouth of an assistant into the nostrils or mouth of the sufferer is not very effectual, as air once respired is not well fitted for the rekindling of the few sparks of life that may be left, but it is in many instances the readiest and indeed the only mode by which respiration can be set up, especially if water or other fluids have found their way into the mouth.

The bellows, if properly constructed for artificial inflation, so that the quantity of air injected may be measured, are no doubt very useful; and if furnished with Leroy's trachea-pipes, or, what is better, with nostril tubes, may safely be employed. About fifteen cubic inches of air may be introduced at each stroke of the bellows, and these should be worked ten or a dozen times in a minute. The lungs should be emptied by compression of the chest before beginning to inflate, and, after each inflation, by compressing the chest and abdomen; but care must also be taken not to employ much force, lest the air-cells be ruptured. Richardson has devised a pocket-bellows for artificial respiration, consisting of two elastic hand-bellows with a single tube for

Fig. 320.—Silvester's Method—Inspiration.

introduction into the nostril. A very efficient mode of introducing pure air into the lungs, especially in children and young persons, is, by the elastic expansion of the walls of the chest. This may be effected by alternately compressing the chest and abdomen with the hand, and then removing the pressure so as to enable the thorax to expand by the natural resiliency of its parietes, and thus, each time it expands, to allow a certain quantity of air to be sucked into the bronchi. A much more efficient method, however, is that recommended by Silvester, and adopted by the Royal Humane Society. It is carried out in the following way. The patient is laid on a flat surface on his back, with the head and shoulders slightly raised on a pillow. The tongue should be drawn out and held forwards. The arms are then to be grasped just above the elbows, and to be drawn gently and steadily upwards above the head and pulled upon slightly, so as to drag on the great pectoral muscles (Fig. 320). In this position they are kept for two seconds; they are then to be brought downwards, and to be pressed for two seconds firmly against the sides of the

chest (Fig. 321); at the same time an assistant may compress the lower ribs and push up the liver and diaphragm. These movements are to be repeated deliberately about fifteen times in the minute, until natural efforts at respiration are induced, when they are to be discontinued and the ordinary means to promote circulation and warmth employed. The quantity of air introduced need not be large; for, by the law of the diffusion of gases, if oxygen be introduced only into the larger divisions of the bronchi, it will rapidly find its way into the ultimate ramifications of these tubes. This last means of inflation has the additional advantage of closely resembling the natural process of respiration, which is one of expansion from without inwards, and not, as when the mouth or bellows are used, of pressure from within outwards. In the one case the lungs are, as it were, drawn outwards, the air merely rushing in to fill up the vacuum that would otherwise be produced within the thorax, by the expansion of its parietes; in the other they are forcibly pressed up from within, and hence there is a danger of rupture of the air-cells. Care must be taken not to use too much violence in compressing the chest. I have

Fig. 321.—Silvester's Method—Expiration.

known a case in which the sternum and several ribs were broken in an old man during the employment of this method. Laborde has recently recommended rhythmic tractions of the tongue at the rate of fifteen to twenty times a minute, as an efficient means of exciting respiratory movements. It is by no means certain, however, that the method acts in any other way than in removing the blockage of the pharynx by the tongue, which falls back in the supine position. In case a battery be at hand, faradization of the phrenic nerve forms a valuable adjunct to the method of artificial respiration. It is thus carried out. It must first be ascertained that the current is of sufficient strength to cause vigorous contraction of the muscles of the ball of the Surgeon's thumb. The person in charge of the battery should stand on the right side of the patient and press one rheophore well down on the phrenic nerve at the outer border of the sterno-mastoid, where the nerve lies on the scalenus anticus, and, while the person in charge of the Silvester method of artificial respiration raises the arms he should press the other rheophore on

the right side of the thorax in the sixth intercostal space; when the arms are depressed he should remove the rheophore. If it is successfully carried out, a distinct rush of air will be heard to enter the mouth as the rheophore is applied to the side.

Inflation of the Lungs with Oxygen Gas is likely to be of great service in extreme cases of asphyxia. I have found by experiment that the contractions of the heart can be excited by inflating the lungs with this gas when the introduction of atmospheric air fails to do so; and there are cases on record in which resuscitation was effected by inflating the lungs with oxygen, when in all probability it could not have been accomplished by any other means. In my Essay on "Asphyxia" will be found a case of resuscitation, in which oxygen was successfully administered by Weeks after the asphyxia had continued three-quarters of an hour.

Whatever means of resuscitation are adopted, they should be continued for at least three or four hours, even though no signs of life show themselves; and after ordinary respiration has been re-established, the patient should be kept quiet in bed some hours. The danger of the supervention of **Secondary Asphyxia** after recovery has apparently taken place is much increased, and indeed is usually brought about, by some effort on the part of the patient that tends to embarrass the partially restored action of the heart and lungs. The patient, being to all appearance resuscitated, is allowed to get up and walk home, when the symptoms of asphyxia speedily return. Should symptoms of secondary asphyxia, such as stupor, laborious respiration, dilatation of the pupils, and convulsions, manifest themselves, artificial respiration should immediately be set up, and maintained until the action of the heart has been fully restored.

Asphyxia from the **Respiration of Noxious Gases**, such as carbonic acid, is best treated by exposing the surface of the body to cold air, by dashing cold water on the face, and by setting up artificial respiration without delay, if the impression of cold upon the surface do not excite these actions. There is a peculiar variety of this kind of asphyxia, which is occasionally met with among infants, the true nature of which was pointed out to me by Wakley, who, as coroner, had abundant opportunities of witnessing it, as it is not an uncommon cause of accidental death amongst the children of the poor. It is that condition in which a child is said to have been *overlain;* the child, sleeping with its mother or nurse, being found in the morning suffocated in the bed. On examination no marks of pressure will be found; but the right cavities of the heart and the lungs are gorged with blood, and the surface is livid, clearly indicating death by Asphyxia. That this accident is not the result of the mother lying upon her child, is not only evident from the *post mortem* appearances, but was clearly proved by a melancholy case to which I was called several years ago, in which a mother, on waking in the morning, found her twin infants lying dead, one on each side of her. Here it was evident, from the position of the bodies, that she could not have overlain both. The true cause of death is partly the inhalation of, and slow suffocation by, the vitiated air which accumulates under the bed-clothes that have been drawn, for the sake of warmth, over the child's head, and partly the diminished supply of oxygen. In such cases, resuscitation by artificial respiration should always be attempted if any signs of life remain.

Asphyxia from the respiration of **carbonic oxide** is more frequent than

Surgeons are apt to imagine. As has already been stated in the chapter on Burns, death often takes place, in cases where buildings are on fire, from poisoning by the respiration of carbonic oxide. According to Leblanc, it is this gas that is the poisonous agent given off in the fumes of charcoal. The effect of the respiration of carbonic oxide gas is to deprive the red corpuscles of their power to carry oxygen, and death takes place rather from the want of oxygen than from the poisonous action of carbonic oxide itself.

The inhalation of oxygen is of service in such cases; but it must be borne in mind that death is generally very rapid.

In cases of **Hanging**, death seldom results from pure asphyxia, but is usually the consequence, to a certain degree at least, of apoplexy, and possibly of simultaneous injury of the spinal cord. In these cases, bleeding from the jugular vein may be combined with artificial respiration.

If there should be a difficulty in setting up artificial respiration through the mouth or nose, as is more especially likely to happen when the patient has been suffocated by breathing noxious gases, or in cases of hanging, tracheotomy or laryngotomy should at once be performed, and the lungs inflated through the opening thus made in the neck.

INJURIES OF THE PHARYNX AND ŒSOPHAGUS.

WOUNDS OF THE ŒSOPHAGUS are met with chiefly in cases of cut-throat, in which, as already stated, they occasion much difficulty by interfering with deglutition.

RUPTURE OF THE ŒSOPHAGUS during vomiting is a very rare accident, of which a few cases have been recorded. The patient has in almost every case been an habitual drunkard, and the accident has occurred after a debauch or over-eating. The rupture always occurs near the cardiac orifice, and may extend into the stomach. In a case recorded by Adams the contents of the stomach passed into the left pleura. The symptoms are sudden severe pain, and a sense of impending death and collapse. Emphysema of the mediastinum extending into the root of the neck has been observed. Death has in most cases followed in less than twenty-four hours; but Meyer has recorded a case in which the patient survived fifty hours, and Fitz one in which death did not occur till the eighth day.

FOREIGN BODIES not uncommonly become impacted in the pharynx and œsophagus, and may produce great inconvenience by their size or shape. If large, as a lump of meat, the substance may lodge in the lower part of the pharynx and occlude the orifice of the glottis, thus at once suffocating the patient. If of smaller size, as a gold plate with false teeth or a coin, it may lodge at the lower end of the pharynx where it is narrowed by the projection of the larynx backwards. Any flat body, such as a coin, if it lodge in this situation, will almost invariably lie with its surfaces looking backwards and forwards. If the foreign body be arrested beyond this point, it will usually be near the termination of the œsophagus. When it is small or pointed, as a fish-bone, pin, or bristle, it may become entangled in the folds of mucous membrane that stretch from the root of the tongue to the epiglottis, or that lie along the sides of the pharynx. In some cases it may even perforate these, penetrating the substance of the larynx, and thus producing intense local irritation, cough, dyspnœa, and suffocation. The foreign body, by transfixing

the coats of the œsophagus, may seriously injure neighbouring parts of importance. Thus, in a case admitted into University College Hospital, a juggler, in attempting to push a blunted sword down his throat, perforated the œsophagus and wounded the pericardium; death resulted in a few days.

The **Symptoms** occasioned by the impaction of a foreign body in the food-passages are sufficiently evident. The sensations of the patient, who usually complains of uneasiness about the top of the sternum, difficulty in swallowing solids, and perhaps an urgent sense of suffocation, lead to the detection of the accident. Should any doubt exist, the Surgeon may, by introducing his finger, explore nearly the whole of the pharynx, and may examine the œsophagus by the cautious introduction of a well-oiled probang.

If the impaction be allowed to continue unrelieved, not only may deglutition and respiration be seriously interfered with, but ulceration of the œsophagus will take place, and an abscess form either behind it or between it and the trachea; or fatal hæmorrhage may ensue by perforation or ulceration of neighbouring blood-vessels.

The **Treatment** must depend upon the nature of the foreign body and its situation. Should it be large, blocking up the pharynx so as to render respiration impracticable, it may be hooked out by the Surgeon's fingers. Should asphyxia have been induced, it may be necessary to perform laryngotomy at once, and to keep up artificial respiration until breathing is fully re-established, when the foreign body can be removed. If it be small or pointed, as a fish-bone or pin, though it have lodged high up, the Surgeon will usually experience great difficulty in its removal, as it becomes entangled between, and is covered in by, the folds of the mucous membrane, where from its small size it may escape detection. In these cases an expanding probang will be found useful. Emetics have been recommended and have been used with success; but it would not be safe to employ them if the foreign body was of any size or firmly impacted, lest the œsophagus should be ruptured during the act of vomiting. After the foreign body has been removed, the patient will for some time experience a pricking sensation, as if it were still fixed. If the impacted body have passed low down into the œsophagus, the Surgeon must deal with it according to its nature. A coin can usually be caught by the instrument known as a "coin-catcher," and removed without difficulty. If the body be smooth and soft, as a piece of meat for instance, it may be pushed down into the stomach by the gentle pressure of the probang. If, however, it be rough, hard, or sharp-pointed, as a piece of earthenware or bone, or a metallic plate with false teeth attached, such a procedure would certainly cause perforation of the œsophagus, and serious mischief to the parts around; in these circumstances, therefore, an attempt at extraction should be made by means of long slightly-curved forceps, constructed for the purpose.

The foreign body occasionally becomes so firmly impacted in the pharynx or œsophagus, that the employment of any force for the purpose of extracting it would be attended with danger of perforating the œsophagus or transfixing the large vessels of the neck; in these circumstances it may become necessary to open the tube and thus remove it. The operation of **Pharyngotomy** or **Œsophagotomy** is seldom called for; if required, it may be performed by making an incision about four inches in length along the anterior border of the left sterno-mastoid muscle, the œsophagus naturally curving somewhat towards

the left side. The dissection must then be carried with great caution between the carotid sheath and the larynx and trachea in a direction backwards, the omo-hyoid muscle having been divided in order to afford room. Care must be taken in this deep dissection not to wound either of the thyroid arteries, more especially the inferior, which will be endangered by carrying the incisions too low. When the pharynx or the œsophagus has been reached, the foreign body may be felt and directly cut down upon. If it cannot be felt a sound should be passed through the mouth, and pushed forwards so that its point may cause the walls of the œsophagus to project, and thus serve as a guide to the Surgeon. This must then be cut upon, and the aperture thus made in the gullet enlarged, by means of a probe-pointed bistoury, to a sufficient size to allow the removal of the extraneous substance. The opening in the œsophagus should then be closed by catgut sutures, not including the mucous membrane, and the external wound should be left freely open to heal by granulation in case the œsophageal incision should fail to unite. The same operation is occasionally performed for stricture of the œsophagus high up, and then a tube is introduced and the wound allowed to close round it. The operation has been attended with considerable success. Agnew gives a table of 36 cases, 27 of which recovered; 31 of these were for the removal of foreign bodies, and of these only four died. When the foreign body is impacted near the cardiac orifice and can neither be pushed down nor drawn up, Richardson, of the Massachusetts Hospital, has shown that it can be removed from below through an opening in the stomach. This operation he successfully performed on a man aged 37, who had accidentally swallowed a plate containing four false teeth eleven months before. It was impacted about two inches above the diaphragm, and was dislodged and removed after considerable manipulation with the index and middle fingers of the right hand, the whole of which was introduced into the stomach. The wound was closed with Lembert's suture, and the patient rapidly recovered. There was some difficulty in finding the cardiac orifice, but experiments on the dead body showed that this may be overcome by putting the small curvature on the stretch, so that it makes a straight line to the œsophageal opening. By doing this forceps can be passed with certainty into the orifice without introducing the hand. The stomach is best exposed by an incision parallel to the left costal margin.

Jacobson has performed a similar operation, but was unable to dislodge a tooth-plate which was impacted 1½ inch above the cardiac orifice; whilst Bull, of New York, extracted a peach-stone which was fixed in a similar position by passing a bougie, with a sponge attached, along the œsophagus from the opening in the stomach and withdrawing it through the mouth.

A hard and perfectly indigestible foreign body may pass through the œsophagus into the stomach. Should it be small, as a coin, or even angular and sharp-pointed, as a plate with artificial teeth, it will, in the great majority of cases, pass safely through the intestines, and may, therefore, be left alone. When it is thus left, the patient should take neither purgatives nor opiates. Both are injurious: the purgatives by increasing the irritation of the bowels and the chance of their being wounded by sharp and projecting points from the plate; the opiates by arresting its progress. The better plan is to keep the patient in bed, perfectly quiet, and to give him an abundance of pultaceous food. By adopting this plan I have succeeded in getting a gold plate, with three molar teeth and a sharp curved

clasping hook at each end, to pass without the slightest difficulty or pain four days after it was swallowed by a gentleman about 25 years of age. No attempt need ever be made to extract small coins from the stomach, as they will always easily pass through the intestinal canal. If the foreign body lodges in the stomach, producing irritation with continued efforts at vomiting, an attempt may be made to remove it through the gullet, but the chances of success are very small. If the attempt be made, an ivory-balled probang should first be passed in to ascertain the situation of the foreign body. After this has been heard and felt, we may try the plan successfully employed by Little—who removed a hooked plate containing five artificial teeth from the stomach of a woman—of introducing a "coin-catcher" so as to search for, secure, and then extract it. In doing this, there is of course a great probability that the mass will be drawn up sideways; and that it may, if broad, hitch in the pharynx, whence it must be detached as well as the Surgeon can manage by a judicious combination of force and skill.

If the body be of such a nature that it is impossible to remove it through the œsophagus, and it is equally unlikely that it can pass safely through the intestines, the operation of **Gastrotomy** must be performed. This is seldom required except in the case of the swallowing of a fork or knife, or some such instrument, either intentionally by a lunatic, or accidentally during drunkenness, or while performing a trick. The foreign body when of this size can usually be felt without difficulty through the abdominal wall. The operation of gastrotomy for the removal of foreign bodies has been singularly successful. Durham states that of ten recorded cases only one died, and in that one œsophagotomy had previously been performed. The operation will be described in the chapter on stricture of the œsophagus.

CHAPTER XXVIII.

INJURIES OF THE CHEST.

WOUNDS OF THE CHEST-WALLS are not of such frequent occurrence now as in the days of duelling. The soft tissues may, however, be contused, torn, or cut. The thoracic muscles, especially the pectorals, are sometimes ruptured by force applied to the arms when abducted or raised above the head. The great pectoral muscle has been torn in a boy who attempted to drop from hand to hand three rungs of a ladder at a time. Extravasation of blood, and even inflammation and suppuration, may result from such injury. Subpectoral abscess may occur from injury of the pectoral muscles, or of the areolar tissue beneath them, or it may form without any apparent cause. The pus must be evacuated early. This may be done by making an incision through the skin and then tearing through the fibres of the muscles, after the manner recommended by Hilton for the emptying of submuscular or deep-seated abscesses.

Wounds of the chest derive their principal interest and importance from the accompanying injury of the lungs, heart, or larger blood-vessels. When the soft parietes alone are wounded, the injury differs in nothing from similar lesions in other parts of the body ; except that it is usually slower in healing, in consequence of the want of rest caused by the movements of respiration. This is especially the case when the muscular parietes are furrowed by bullets. If the Surgeon be in doubt whether the cavity of the chest have been penetrated or not, he may endeavour to ascertain this point by careful examination with the finger, but he should never introduce a probe ; it is better for him to wait and to be guided in his opinion by the symptoms that manifest themselves, rather than, by probing the wound, to run the risk of converting it into what he dreads—a penetrating wound of the chest.

FRACTURES OF THE BONES OF THE CHEST.

FRACTURE OF THE RIBS AND COSTAL CARTILAGES.—These injuries may occur in two ways : 1st, from direct violence, the part that is struck being driven in towards the thoracic cavity, and thus broken ; 2nd, from indirect violence, the fore part of the chest being forcibly compressed, so that the rib is bent outward, and snaps. When the injury is the result of direct violence, and the broken fragments are forced in, the pleura, lung, liver, or diaphragm, may be wounded, thus giving rise to the most serious and fatal consequences, such as hæmorrhage, emphysema, and inflammation of the parts injured. When it is occasioned by indirect violence, as the fracture takes place in an outward direction, the thoracic organs may be contused, but they are not likely to be punctured by the fragments. In some rare cases, the ribs have been known to be broken by the violent contraction of the abdominal muscles during labour.

Fracture of the ribs may be *single; multiple* when several, or even all the ribs on one side, or several on both sides, are fractured; *simple*, as in ordinary violence; and *compound*, as in gunshot injuries.

Any one of the ribs may be broken, and frequently several are fractured at the same time. The middle ribs, from the fourth to the eighth, are those that oftenest give way, being most exposed, and at the same time fixed. The first and second ribs are seldom broken, being protected by the clavicle and shoulder. When they are fractured it is usually the result of gunshot violence, or, if from some of the ordinary accidents of civil life, the clavicle will be broken as well. But this is not an invariable complication. I have seen fractures of the first two ribs from a fall, without any injury to neighbouring bones. This fracture is always very dangerous, on account of the liability to injury of important subjacent structures. The lower ribs, being less firmly fixed than the others, commonly escape, unless very great and direct violence be inflicted upon them. Any part of a rib may be broken by direct violence; but when the fracture is the result of compression of the chest, it is usually the point of greatest convexity or the neighbourhood of the angle of the rib that gives way. These indirect fractures commonly occur in elderly people, in whom the elasticity of the thoracic parietes has lessened as the result of age, and they are peculiarly liable to occur in some cases of general paralysis of the insane, in which the bones are weakened by atrophy.

Symptoms.—The chief symptom is a sharp pricking and catching pain at the seat of injury, increased by breathing deeply, or by coughing. In order to avoid this, the inspirations are shallow, and the breathing is principally diaphragmatic. On placing one hand on the sternum, and the other on the spine, and pressing gently, the patient will complain of pain at the seat of fracture. This is often a valuable means of diagnosis. On laying the hand over the seat of injury, and desiring the patient to cough, crepitus may often be felt; and in most cases this is audible on applying the ear to the chest. The diagnosis of the fracture is necessarily more easily made where the ribs are thinly covered, than where they lie under the muscles of the back. Occasionally the outline of the rib will be found to be irregular; and in some instances, where several ribs are broken, the whole side of the chest is flattened and depressed. Besides these local symptoms, special complications resulting from laceration of the pleura and lung, such as hæmoptysis, pneumothorax, or emphysema, may occur. These complications are much less frequent than might *a priori* be supposed, owing to the fracturing force being usually indirect, causing the rib to bend outwards, and thus to break away from, instead of into, the chest. The danger of fractured ribs, indeed, depends wholly on the thoracic complications, and these will be occasioned chiefly by one of two conditions: either by the forcible driving in of the fractured ends, as from the kick of a horse, so that the pleura and lung are wounded by the sharp and ragged fragments; or else by a large number of ribs being broken by a severe squeeze of the chest, and the thoracic organs injured by the general compression. It is surprising, however, what an extent of injury of this kind may take place without serious consequences. I have had under my care a young man, who, in consequence of a crush of the chest, in a railway accident, had the upper seven ribs broken on the right side, and the lower five on the left, the chest, especially on the right side, being greatly flattened; he recovered without a bad symptom. In gunshot injuries of the chest, with

splintering of the ribs, there is always wound of the contained organs, which becomes the main source of danger to the patient and the chief point to which the attention of the Surgeon has to be directed.

Treatment.—In treating fractured ribs, the Surgeon need not concern himself so much about the union of the fracture, as about the prevention of pain to the patient in breathing, and of the subsequent occurrence of serious inflammation or other mischief within the chest.

Any displacement that may exist usually remedies itself. The chest-wall, even when extensively flattened, gradually expands under the influence of the respiratory movements. If, however, a portion of the rib continue depressed, it had most certainly better be left so; the suggestions that have been made for elevating these fractures by means of sharp hooks and screw-probes being more likely than the continuance of the depression to occasion serious mischief to the contents of the thorax. In order to prevent undue motion of the broken bone and the consequent irritation produced by its puncturing the pleura or lung, the movements of the injured part of the chest must be restrained. If one or more ribs be broken on one side, this can usually be accomplished by applying strapping to the injured side only. A sufficient number of strips, two inches broad and long enough to reach two inches beyond the middle line in front and behind, may be firmly applied, overlapping each other in fully half their width. The strips should be applied from above downwards, and each should be adjusted at the end of the movement of expiration. A broad flannel roller may now be carried circularly round the chest, but not so firmly as seriously to hamper the movements of the undamaged side. When the fractures have occurred on both sides of the chest, a broad strip of plaster may sometimes with advantage be carried completely around it. In some cases, however, more particularly in those in which the fragments are driven inwards, it will be found that the constriction of the chest by bandage or plaster becomes unbearable, producing great pain and dyspnœa. In these circumstances, all constriction must be removed, and the patient allowed to breathe easily, but he must be confined to bed. If the lower ribs be broken, the diaphragm may become irritated by the projection inwards of the fractured bone; and if the plaster and bandage be applied too tightly, spasmodic action of that muscle may ensue, occasioning distressing hiccup and dyspnœa.

The **average period of union** of a fractured rib is three weeks. There is always a considerable amount of callus thrown out in the repair, on account of the constant movement that necessarily takes place between the broken ends in respiration.

In **gunshot injuries of the chest, with splintering of the ribs**, all broken spicula of bone must be carefully picked out, and the wound cleaned with an antiseptic lotion when possible. It must then be covered with carbolic gauze, iodoform, salicylic wool, or some other efficient antiseptic application. In such cases, the grave injuries usually inflicted on the intrathoracic organs will absorb the Surgeon's attention.

It occasionally happens that fracture of one or more of the **Costal Cartilages,** especially the fifth, sixth, seventh, or eighth, is produced by direct violence. They may be separated from their junction with the rib, or broken across the middle. The existence of fracture may be determined by the pain on pressure, mobility, and irregularity at the seat of injury. The same treat-

ment is required for this fracture as for a broken rib; the broken cartilage most commonly uniting by a bony callus which surrounds the fractured ends.

Fracture of the Sternum.—The sternum is not often broken. The accident occurs usually from very severe and direct violence; and when this is applied on the fore part of the chest, the ribs or costal cartilages are more likely to suffer. The elastic support furnished to the sternum by these structures explains in a great measure the rarity of its fracture. It may also be produced by violent bending forward of the body after the spine has been broken. The bone has been known to be broken, though very rarely, by violent straining muscular efforts during parturition. Its fractures are always transverse, usually single, but sometimes multiple. I have seen it broken into three nearly equal fragments by a fall from a scaffold. The displacement of one of the fragments is sometimes considerable, the upper fragment being almost invariably behind the lower; but even if there be but little deformity, the very superficial situation of the bone will always enable the Surgeon to judge of the exact nature of the injury it has suffered, the signs of which resemble those of a fractured rib.

The **Treatment** must be conducted on the same principles as that of a broken rib, and presents nothing special. Indeed, when fracture of the sternum occurs from external violence, it is commonly associated with fracture of the ribs, near the angles; and then the chest-bandage or plaster answers equally for both injuries. Should the sternum be broken during parturition, the patient should be made to sit up in bed, with the shoulders supported and leaning slightly forwards, so as to take off the tension of the abdominal muscles. If a portion of broken sternum be depressed, it should be left undisturbed, unless it can be readily got into position by placing a firm pillow under the back and allowing the shoulders to fall backwards. If this fails, the displacement will probably give rise to no serious inconvenience, while any attempt to remove it by surgical interference might be attended with the greatest danger.

INJURIES OF THE LUNG.

Contusion of the Lung without injury to the pleura covering it may happen from severe blows on the chest, as from falls from horseback or kicks on the side. It may be complicated with fracture of one or more ribs; but this is not necessarily a concomitant of the injury. The symptoms are as follows. After the receipt of the blow, the patient is seized with difficulty in breathing, which is apt to become paroxysmal, so as to resemble asthma. There is expectoration, at first of mucus untinged with blood. On listening at the chest, coarse crepitation, with some dulness on percussion, will be found over the injured part of the lung. After some days, the patient coughs up a small quantity of dark, coagulated, viscid fluid; and the sputa may be tinged for some time afterwards. The dyspnœa and cough are greatly relieved, and recovery gradually takes place.

It is probable that in these cases the lung is ecchymosed at the time of the injury, and that the blood extravasated in its tissue gradually breaks down, being then discharged by coughing in the viscous, semi-coagulated state above described—very different from the florid frothy sputum of a recent lung wound.

RUPTURE OF THE LUNG, that is to say, a contused wound with laceration of the visceral pleura, has occasionally been observed as the result of violent compression in some cases without fracture of the ribs. Thus, a young woman was brought into University College Hospital a few years ago, who had thrown herself from a first-floor window, and had fallen with her chest against an iron bar. She died soon after admission, and it was found that death had resulted from hæmorrhage from a laceration of the root of the right lung. The chest walls were extremely elastic, and no fracture of the ribs had taken place. The symptoms are identical with those of a wound of the lung. Rupture of the lung is a dangerous accident, but not necessarily fatal.

WOUND OF THE LUNG is the most common, and one of the most serious complications of injuries of the chest. Wounds of the lung may be divided into those which communicate with the external air by a wound penetrating the walls of the thorax, and those which do not. In an organ like the lung which contains air, this distinction might seem to be of little importance; but as has already been pointed out, it is the dust of the air, and not the gases, which gives rise to decomposition of extravasated blood or inflammatory effusions. The well-known experiment of Tyndall, by which he showed that the residual air—that is to say, the last part of the air driven out from the smaller bronchial tubes and the air-vesicles by forced expiration—contains no dust, proves that all the solid particles floating in the atmosphere are deposited in the larger tubes; and, consequently, unless the wound of the lung be of sufficient depth to open these, there is no reason to fear that decomposition will take place in the cavity of the pleura, even though a considerable quantity of air may escape into it. Wounds of the lung also vary greatly in severity—from the superficial puncture produced by the pointed fragment of a broken rib, to a deep stab by a sword-thrust, or the wound produced by a fragment of shell or a bullet. The general constitutional effects will necessarily vary in accordance with the nature and extent of the injury.

The pleura may be opened at any part, and it is important to remember its anatomical relations. Its upper part extends into the root of the neck from one to two inches above the anterior end of the first rib, or, according to Pansch, from half an inch to one and a half inches above the clavicle. Below, the limits of the pleuræ are as follows: behind they both reach to the twelfth rib, and sometimes a little below it; in the axillary line the right pleura extends to the lower border of the ninth rib, and the left to the lower edge of the tenth; in front the right pleura reaches to the junction of the seventh rib with its cartilage, and the left a little lower. Thus, a stab in the neck one inch and a half above the clavicle may reach it, and a shot in the back that shatters the twelfth rib will wound it in its inferior pouch, where it is reflected off the last rib on to the diaphragm. In a penetrating wound of the chest, so low down as this, the diaphragm comes into such close contact with its posterior walls that it could scarcely escape injury. The abdominal cavity would thus be opened, and some of its viscera probably injured. As the lung does not descend below the tenth rib, it could be wounded only as low as the ninth intercostal space in the back, unless the tenth rib itself were penetrated.

The **Symptoms** of a wound of the lung are usually sufficiently well marked, though they necessarily vary with the extent of the injury. There is, in the first place, the immediate shock that usually accompanies the infliction of an

injury on an important internal organ, in severe cases amounting to extreme collapse. The patient is at the same time seized with considerable difficulty of breathing, and in consequence of the injury to the parietes, the respiration is as a rule chiefly abdominal; this is followed by much tickling and irritating cough, and the expectoration of frothy bloody mucus; or, if a large vessel is wounded, great quantities of pure blood may be brought up. On auscultating the chest immediately after the infliction of the injury, loud coarse *râles* will be heard, caused by the presence of blood in the smaller bronchial tubes. In the least severe cases, in which the surface of the lung is merely pricked by a fragment of a broken rib, the occurrence of subcutaneous emphysema may be the only certain indication of the injury.

Complications.—In order to save repetition and to make the subject more clear, it will be better first to describe the complications that may attend wounds of the lung. The principal dangers arise from bleeding, both external and internal, the occurrence of Hæmothorax, Pneumothorax, Emphysema, Pneumonia, and Empyema.

1. The **Hæmorrhage** varies with the part of the lung wounded, and the extent of the wound. If the large vessels near the root are implicated, death occurs almost instantaneously from loss of blood and suffocation. If the surface only is injured, the bleeding may be very slight. When it is abundant the patient spits up large quantities of florid frothy blood, a considerable amount of which may be swallowed and subsequently vomited. If it do not prove fatal, this bloody expectoration generally ceases in a great measure in the course of forty-eight hours, giving way to sputa of a rusty character. If there be a free external wound, there may also be copious bleeding from it; but not unfrequently the blood finds its way into the pleural sac rather than through the external aperture and accumulates in it. If there is no external wound, such blood as is poured out from the surface of the lung must necessarily find its way into the pleura. Death may arise either from the exhausting effects of this internal and concealed hæmorrhage, or from suffocation through the pressure exercised on the lungs by the blood in the pleura. Although bloody expectoration, to some extent at least, is an almost necessary and invariable accompaniment of a wounded lung, yet I have seen a laceration in that organ three inches in length, occasioned by the projection of broken ribs, which proved fatal on the seventh day from hæmothorax and pleuritic effusion, unattended with any expectoration of blood, or other positive sign of wound of the lung. The blood in these cases would probably be infiltrated into the loose tissue of the lung around and above the wound, where it would coagulate so as to offer a barrier against its escape into the bronchi, while it was being poured out where least resistance was offered to it—viz., at the point of injury in the pleura. The symptoms of this internal hæmorrhage, **Hæmothorax**, are those that generally characterize loss of blood, such as coldness and pallor of the surface, small weak pulse, and a tendency to collapse with increasing dyspnœa. The more special signs consist in an inability to lie on the uninjured side, with, in extreme cases, some bulging of the intercostal spaces, and an ecchymosed condition of the posterior part of the wounded side of the chest. If there is an open wound there will be occasional gushes of blood from it when the patient coughs. The most important signs are furnished by physical examination of the chest. As the blood gravitates towards the back of the chest, between the posterior wall and the diaphragm, there will be gradually

increasing dulness on percussion in this situation, with absence of respiratory murmur and of vocal fremitus. In the upper and anterior part of the lung air continues to enter, but as the pressure increases and the lung becomes more completely collapsed, the vesicular murmur will be lost, and the breath-sounds become tubular in character.

An ecchymosis of the loins described by Valentin, and noticed by Larrey and others, occasioned by the filtration of blood through the wound or rent in the pleura costalis into the areolar tissue of the chest, has been looked upon by some Surgeons as pathognomonic of hæmothorax; its importance, however, is secondary to that of the auscultatory signs, as in many cases it has not been met with, and in others of non-penetrating wounds of the chest it has occurred.

2. **Emphysema**, or the infiltration of air into the areolar tissue of the body, and **Pneumothorax**, or the accumulation of air in the cavity of the pleura, are occasional complications of a wounded lung. Emphysema of a limited character without pneumothorax is a very common complication of superficial wounds of the lung from simple fracture of the ribs, and is of no importance. In such cases the two layers of the pleura remain closely applied to each other and the air passes through these without filling the pleural cavity. More extensive emphysema is almost always associated with air in the pleural cavity. These accidents occur more commonly when the external wound is small and oblique than when it is large and direct, and often happen in those cases in which the lung is punctured by a fractured rib, without there being any external wound. The mechanism of traumatic emphysema in such cases is as follows. The two layers of the pleura, being punctured and torn, and the lung wounded, a quantity of air is sucked into the pleural sac at every inspiration, either through the external wound, or, if none exist, from a hole in the lung, thus giving rise to pneumothorax. At each expiration, the air that thus accumulates in the pleural sac, being compressed by the descent of the walls of the chest, is pumped into the areolar tissue around the edges of the wound; and if this be oblique and valvular, or if no external wound exist, the air being unable to escape wholly through it, finds its way at each succeeding respiration further into the large areolar planes, first about the trunk and neck, and eventually, perhaps, into those of the body generally. Under no circumstances can any air find its way back into the bronchial tubes, for although a wound in the lung allows air to pass readily in the direction of the pleura, it offers a valve-like resistance to its passage in the opposite direction. Though this is the way in which the most marked cases of emphysema occur, it may be occasioned otherwise. Thus, for instance, I once had under my care a woman who had extensive emphysema of the areolar tissue of the trunk from fractured ribs, but without any pneumothorax, the lung having been wounded at a spot where it was attached to the walls of the chest by old adhesions, and the air having passed through them into the areolar tissue of the body, without first entering the cavity of the pleura. I have also seen extensive emphysema occasioned by the apex of the lung being wounded by the fragments of a comminuted clavicle. Hilton has described another form of traumatic emphysema that arises without any external wound. The air passes along the root of the lung into the middle, and thence into the superior mediastinum; running up along the great vessels and the œsophagus, it passes into the neck between the layers of cervical fascia which enter the thorax

in front of the great vessels and behind the œsophagus respectively. From these the carotid and subclavian vessels, with their nerves, derive sheaths, so the air now runs along these structures into the limbs and neck.

The air which escapes from a wound of the lung is, as before stated, thoroughly filtered, and has no tendency to give rise to putrefaction of the extravasated blood or inflammatory effusions in the parts about the wound, and in the vast majority of cases of simple fracture of the ribs, complicated by a slight wound of the lung and subcutaneous emphysema, no suppuration follows the accident. I have, however, seen extensive suppuration in the areolar tissue, so that the broken parts of the fractured ribs lay bathed in pus, when the emphysema was the result of puncture of the lung by the broken rib, without any wound in the skin.

The *Symptoms of Emphysema* are very distinct. There is a puffy diffused swelling, pale in colour, and crackling when pressed upon, at first confined to the neighbourhood of the wound, if there be one externally; if not, making its appearance opposite the fractured ribs, and gradually extending over the upper part of the trunk and neck. To these parts it is usually limited; in some cases, however, which are happily rare, the swelling becomes more general, the body being blown up to an enormous size, the features effaced, movement of the limbs interfered with, respiration arrested, and suffocation consequently induced; after death, air has been found in all the tissues, even under the serous coverings of the abdominal organs. The rapidity with which the emphysema diffuses itself will depend largely upon the nature of the opening in the chest-wall, whether valvular or direct, and upon whether the patient coughs or not—coughing, if violent, causing very rapid and extensive infiltration of air over the body. I have seen in such a case the scrotum blown up to the size of a cocoa-nut five minutes after the chest had been punctured. In *traumatic pneumothorax* the auscultatory phenomena are very distinctly marked; there is a diminution or complete absence of the respiratory murmur and of vocal fremitus on the affected side, with loud tympanitic resonance on percussion, displacement of viscera, and considerable distress in breathing. If the pressure in the pleura becomes very great, respiration may be completely arrested by pressure on the opposite lung.

3. **Pneumonia.**—Every wound of the lung is necessarily followed by a localised traumatic inflammation, limited to the parts actually injured. The inflammatory exudation fills the air-vesicles, and thus causes a consolidation of the lung at the injured spot. This is a necessary stage in the process of repair, and in subcutaneous injuries has little or no tendency to spread. In cases complicated by the admission of unpurified air from without, decomposition of the extravasated blood and inflammatory effusion frequently occur, and the presence of the irritating products of putrefaction in the track of the wound may lead to an extension of the inflammation, with suppuration, and occasionally gangrene of a portion of the lung. More commonly the lung collapses, in consequence of the pressure of blood and inflammatory effusion in the pleura, and at the *post-mortem* examination, if the patient should die, the consolidation of the lung is found to extend scarcely beyond the parts actually injured by the missile or weapon by which the wound was inflicted. The comparative rarity of spreading pneumonia in cases of gunshot wound of the lung is specially commented on in the Reports of the Civil War in America, and was noted also by Klebs and Socin in the Franco-German War of 1870.

The simple localized traumatic inflammation consequent on an injury causes but slight constitutional disturbance, and it is only in exceptional cases that it could give rise to definite physical signs. There may be a little fine crepitation, and possibly recognizable dulness; but more commonly the physical signs are obscured by hæmorrhage into the lung substance, and into the cavity of the pleura. The rusty sputa are more the consequence of the hæmorrhage into the air-vesicles than of inflammatory hyperæmia. Should spreading septic inflammation set in, the constitutional symptoms are much more grave, very high fever being caused by absorption of the products of putrefaction, the temperature reaching 104° F. or 105° F. It may then occasionally be possible to recognize the ordinary signs of pneumonia—hurried respiration, fine crepitation, dulness on percussion, increased vocal fremitus, tubular or bronchial breathing, and increased vocal resonance,—but far more commonly all these signs are wanting in consequence of the simultaneous inflammation of the pleura, with effusion into its cavity. The pneumonia that occurs as a consequence of injury differs essentially from acute croupous pneumonia. The disease has of course no fixed locality, starting as it does from the wound, and it has much less tendency to spread. Moreover it occurs most frequently in a collapsed or partially collapsed lung, and consequently there is not the same distension of the air-vesicles with inflammatory exudation. It is a most dangerous complication but not a hopeless one. If free drainage be provided from the pleura, the mischief may cease to spread, granulations may spring up, and the wound in the lung may gradually close.

Foreign bodies are frequently carried into the substance of the lung in gunshot wounds of the chest. If these are metallic, they may become encysted; if non-metallic, as pieces of clothing, they more commonly give rise to suppuration; and should the patient recover, they may ultimately find their way into the bronchi, and be coughed up.

4. **Pleurisy and Empyema.**—Whenever the pleura is wounded, whether it be by a fractured rib or by a direct open wound, and whether the lung be injured or not, localized traumatic inflammation necessarily results, and the first stage in the repair of the injury in the serous membrane is adhesion of the two opposed surfaces by means of the inflammatory exudation. Afterwards firm fibrous adhesions are formed between the parietal and the visceral pleura at the injured spot, thus to a certain extent obliterating the serous sac. Subcutaneous injuries of the pleura, such as are made by the ends of a broken rib, rarely give rise to any serious trouble. The inflammation remains strictly limited to the injured spot, and shows little tendency to spread. Even when the physical signs have shown that some amount of blood has been extravasated into the cavity of the pleura, the inflammation rarely reaches the stage of suppuration unless there is an external wound. If there is an external wound, the condition is always one of considerable danger. The cavity of the pleura is partly filled with extravasated blood and inflammatory exudation, that is to say, with putrescible matter, to which the air has free access through the external wound; at the same time, in most cases, the drainage by the wound is very imperfect. Decomposition naturally follows, and the decomposing matter sets up the most intense inflammation of the pleura, rapidly reaching the stage of suppuration. The lodgment of a foreign body in the pleural cavity or an unhealthy constitutional condition of the patient necessarily favours the formation of pus in the pleura. In wounds of

the pleural cavity which follow this course, the effused fluid is at first serum, with some flakes of lymph floating in it, and it is generally mixed with blood from the wounded lung. The effusion takes place very rapidly, so as to half fill one side of the chest in two or three days. By about the third day it becomes turbid, and before the end of a week it assumes the character of pus. The discharge from the wound is often abundant, offensive, and extremely irritating to the skin. The constitutional symptoms are most severe, the temperature rising to 104° F. or 105° F. The patient may die during the first week from absorption of the products of putrefaction. Should he survive till suppuration is fully established, the intensity of the symptoms subsides, the cavity may gradually close, and recovery take place; or death may ensue from hectic or exhaustion from prolonged suppuration.

The presence of fluid in the pleura may be recognized by the physical signs; dulness on percussion and absence of respiratory murmur at the lower and posterior parts of the chest, up to a level which has a gradual tendency to ascend, and which varies according as the patient is upright or recumbent; vocal fremitus is abolished over the fluid, and vocal resonance is muffled. At the border of the fluid there is occasionally ægophony. In cases in which there is no external wound, or in which it has been closed, the whole side of the chest may be filled with fluid. There is then complete absence of all breath and voice sounds and of vocal fremitus, with increase of size on measurement, bulging of the intercostal spaces, and compression of the lung against the spine; and, if the left pleura be filled, displacement of the heart towards the right side—if the right pleura, descent of the liver below its normal level, and displacement of the heart to the left. When the pleuritic effusion and extravasation reach such a degree as this, there is necessarily great dyspnœa, and death will usually speedily ensue. If there be air as well as fluid in the cavity of the pleura, it can be recognized by the combination of the signs of pneumothorax at the upper part of the chest, with those of fluid at the lower. Occasionally distinct splashing sounds may be produced by gently shaking the patient. If it is desired to ascertain the nature of the fluid in the pleural cavity, a small quantity may be drawn off by means of an exploring syringe.

Collapse of the Lung.—In wounds of the chest, as soon as air is admitted to the cavity of the pleura the atmospheric pressure on the surface of the lung and within the air-vesicles becomes equal and it would naturally be supposed that the lung would at once collapse by virtue of its own elasticity. This, however, is not always the case. The chest may be largely opened and yet no collapse may take place. This seems most probably to be due to the adhesion of the two smooth moist pleural surfaces to each other. When collapse of the lung occurs early it is often due to air entering the pleura during inspiration, either from the lung or from without, and in consequence of the valve-like action of the wounded lung, or an oblique external wound, being unable to escape during expiration; consequently, as the chest-walls descend, the lung is squeezed by the compressed air. This may be repeated at each respiration till no further collapse of the lung is possible. In the later stages it may be due to compression by blood or by inflammatory effusion.

The possible complications of wounds of the lung having been described, we are now in a position to consider the different varieties of these injuries.

Subcutaneous Wounds of the Lung from Fractured Ribs.—Slight injuries to the lung are extremely common in fractures of the ribs by direct violence, but as has already been pointed out, they are much less likely to occur in fractures by indirect violence, as in these the pointed ends of the fragments are directed outwards. These injuries rarely extend deeply into the lung. The usual symptoms are slight hæmoptysis, ceasing by the second day, followed by rusty sputa and limited dulness round the injury, and, possibly, at the base of the pleural cavity, from extravasated blood. There may be a little coarse crepitation from blood in the lung. Emphysema is of frequent occurrence, but pneumothorax is a rare complication ; it seems that a little air readily finds its way across the pleural cavity, without any separation of the visceral from the parietal pleura, probably in consequence of the natural cohesion of two smooth moist surfaces. Occasionally the absence of air in the pleural cavity in these cases may be due to the presence of adhesions. The emphysema in these cases is rarely extensive. These slight wounds of the lung in a healthy subject scarcely add to the gravity of the case, and require no treatment beyond that of the fractured rib.

More severe wounds of the lung may occur from fractures of the ribs, accompanied by pneumothorax, extensive emphysema and hæmothorax. These are occasionally followed by pleurisy with effusion, or even empyema. The majority of these severe injuries, however, do well if the patient is healthy and there is no open wound.

Penetrating Wounds of the Thorax with Wound of the Lung.—A penetrating wound is recognized by the presence of an external opening, through which air is frequently drawn in and out during respiration, with the signs, already indicated, of wound of the lung. These cases are always serious, as owing to the admission of air from without there is great risk of the occurrence of septic pleurisy and pneumonia. Moreover, in a large proportion of cases the injury to the lung extends more deeply than any wound which can possibly be inflicted by a broken rib.

Wounds of the Lung by sharp penetrating instruments, as knives or swords, are specially liable to be complicated by profuse hæmorrhage, both into the pleura and into the air-tubes. When they penetrate the chest-wall obliquely, so as to leave a valved opening, they may give rise to emphysema and pneumothorax ; in fact, it is in this class of cases that these conditions have most commonly been met with in an extreme degree. Septic pleurisy and empyema are common complications, but from the clean, incised character of the wound and the absence of foreign bodies carried into it there is a fair hope of preventing these complications and obtaining union of the external wound by the first intention if proper treatment be adopted.

Wounds of the Lung by blunt instruments, as in bullet or shell wounds or in machinery accidents, form by far the gravest class of these injuries. In consequence of the form and size of the external opening, emphysema is a somewhat rare complication, and when air is present in the pleura it is seldom at any degree of pressure. Hæmothorax, to a greater or less extent, is always present, and in the majority of cases, as the external wound can scarcely heal by the first intention, septic pleurisy and empyema follow the injury. It is sometimes complicated by spreading inflammation of the lung, terminating i[illegible]ration or gangrene. These cases are frequently complicated by the [illegible] of foreign bodies, such as bullets or pieces of clothing.

The **Prognosis** in wounds of the lungs is necessarily extremely unfavourable if the injury be severe. The danger will depend greatly upon whether the wound be open or subcutaneous, upon the nature of the instrument inflicting it, and upon its extent. If the lung be wounded by the sharp end of a broken rib, recovery usually ensues. Punctured wounds of the chest, penetrating the lungs, are always very serious ; but here the danger will depend partly on the depth of penetration, partly on the size of the instrument causing the wound. The nearer the wound penetrates to the root of the lungs, the greater is the danger of hæmorrhage from the larger vascular trunks. Gunshot wounds of the chest are far more dangerous than stabs, owing partly to the laceration attendant on a bullet wound, but chiefly to the fact that the external wound can rarely heal without suppuration and consequently, unless such complication be prevented by antiseptic treatment, septic pleurisy and empyema, and perhaps also pneumonia, are almost certain to occur. The danger of these wounds is also increased, in many cases, by the lodgment of the bullet or other foreign bodies.

In the Report of the American Civil War, a table is given of 1609 cases of penetrating wounds of the chest, collected from various sources, including the reports of Mouat on the New Zealand War, Chenu and Matthew on the Crimean War, Stromeyer on the Danish War, and others. Of these 1049 died, being an average mortality of 65·2 per cent. In the American Civil War 8715 cases were recorded, with 5260 deaths, or 62·6 per cent. The highest mortality recorded was in the Crimean War, in which 91·6 per cent. of these cases terminated fatally amongst the French troops, and 79·2 amongst the English. Longmore points out that the apparently great mortality in the Crimean returns was due largely to the proximity of the field-hospitals to the trenches, where the patients were wounded ; if they had been wounded in the ordinary circumstances of a battle, many of them would never have reached a hospital. The great danger and principal cause of death in these injuries is unquestionably the hæmorrhage that ensues. This may prove immediately fatal if one of the larger pulmonary vessels be divided. As the bleeding is most abundant at and shortly after the receipt of the wound, Hennen states that, if the patient survive the third day, great hopes may be entertained of his recovery. After this period, the chief source of danger is the occurrence of septic inflammation in the pleura and sometimes also in the injured lung, the probability of the occurrence of which is greatly increased in gunshot injuries by the frequent lodgment of foreign bodies within the chest. The immediate cause of death at this stage is the accumulation of decomposing inflammatory effusion in the pleural cavity and the absorption of the products of putrefaction. This may prove fatal from the fourth to the eighth day. Emphysema is seldom a dangerous complication, though it may become so if very extensive and if it be allowed to increase unchecked.

If both lungs be wounded at the same time, the result is almost inevitably fatal, either by the abundant hæmorrhage suffocating or exhausting the patient, or else by induction of asphyxia in consequence of air being drawn into both the pleural sacs. This, however, does not necessarily result ; and there is a sufficient number of cases of recoveries after stabs or bullet wounds traversing both sides of the chest on record to show that collapse of the lungs and consequent asphyxia do not necessarily result from this double

Subcutaneous W[illegible] been determined experimentally on animals by injuries to the lun[illegible] both pleural cavities is not necessarily fatal violence, but as ha[illegible] by Bilton Pollard, in which a child falling from in fractures by ind[illegible] was impaled on the area railings. Both are directed outw[illegible] and recovery followed. The usual symp[illegible] of the chest, implicating the lungs, must have followed by rusty [illegible] of danger that have just been indicated and the base of the p[illegible] coarse crepitatio[illegible] cases of *injury of the lung from a broken rib* rence, but pne[illegible] is very simple. The injured side of the chest readily finds i[illegible] spine to sternum so as to restrain its movements and visceral from [illegible] There are two conditions in which it is especially cohesion of tw[illegible] bandage or strap the whole chest. The first is when pleural cavity [illegible] broken rib are sharp and angular, and, projecting inwards emphysema [illegible] produce pain, distress, and no slight danger of further lung in a be[illegible] if pressed down upon them; secondly, when the lung no treatmen[illegible] by the effusion of air, serum, or blood into the pleural

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If there is no antiseptic lotion at hand the Surgeon should defer the examination till the patient has reached the hospital. Nothing is more certain to give rise to septic pleurisy than the introduction of a dirty finger.

In *Bullet wounds of the Lung* the treatment will chiefly depend upon the nature of the external wound. In a case in which one of the modern bullets has passed through the chest producing small almost clean-cut apertures, the Surgeon will probably best consult the safety of the patient by abstaining from all interference beyond thorough cleansing of the skin with an efficient antiseptic solution and the application of an antiseptic dressing. If the bullet remain in the chest, the aperture must be sufficiently enlarged to allow the introduction of the finger, purified by some antiseptic fluid. The Surgeon must not go too deeply or perseveringly in search of the foreign body, lest he excite more irritation than it would if left alone.

Large wounds must be left freely open, whilst medium-sized ones may need enlarging, so as to favour the escape of any foreign body which may have been left in, or of extravasated blood or inflammatory effusions. Careful antiseptic treatment of such cases is most important, and in the absence of the necessary means for carrying this out, the patient's chance of recovery will be increased by a free provision for drainage and the application of some dry absorbent dressing.

The **Constitutional Treatment** of wounds of the lung presents nothing peculiar. During the first few hours the chief danger is from loss of blood, and as the feeble state of the circulation during the state of shock that immediately follows the injury is favourable to the arrest of hæmorrhage, the patient should not be prematurely roused by the administration of stimulants. He must be kept lying on the injured side, and have ice to suck, or a little iced milk and soda-water, or barley-water, to drink, when these are obtainable. He must be forbidden to talk, and kept at perfect rest. If no complications ensue, he must be kept on moderate diet for a few days, after which he may take such food as he is inclined for.

Treatment of the Complications of Penetrating Wounds of the Lung.—Profuse *hæmorrhage* is a common complication in all wounds of the chest. It may occasionally come from a wounded intercostal or internal mammary artery, and must then be treated by the method described on p. 476. If the hæmorrhage come from the pulmonary tissue, the first indication is to diminish the quantity and force of the blood circulating through the lungs, and thus, by lessening the impulse of the heart and increasing the tendency of the blood to coagulate in the smaller vessels, to endeavour to arrest the hæmorrhage from these organs. If the hæmorrhage have been very abundant, the collapse and fainting consequent upon this may tend to induce a natural arrest of the bleeding, which thus often spontaneously ceases on the supervention of syncope. Should the hæmoptysis, however, continue or return from time to time, what should be done? Here a very considerable discrepancy of opinion exists amongst Surgeons; the question at issue being whether venesection should be adopted with the view of restraining the hæmorrhage, or whether the patient should be treated by rest, low diet, ice, digitalis, and similar remedies. Up to the close of the Crimean war, the most experienced Surgeons were unanimous in their opinion that the patient's safety lay in free and repeated venesection. John Bell, Hennen, and Guthrie, all concurred in urging the necessity of free venesection so as to keep down the action of the heart. According to

injury, which indeed has also been determined experimentally on animals by Cruveilhier. That perforation of both pleural cavities is not necessarily fatal is well shown by a case recorded by Bilton Pollard, in which a child falling from a height of more than thirty feet was impaled on the area railings. Both wounds were closed with sutures and recovery followed.

The **Treatment** of wounds of the chest, implicating the lungs, must have reference to the various sources of danger that have just been indicated and to the nature of the wound.

The **Local Treatment** in cases of *injury of the lung from a broken rib* without an external wound is very simple. The injured side of the chest should be strapped from spine to sternum so as to restrain its movements and leave the sound side free. There are two conditions in which it is especially inadvisable tightly to bandage or strap the whole chest. The first is when the fragments of the broken rib are sharp and angular, and, projecting inwards on the pleura and lung, produce pain, distress, and no slight danger of further injury to these structures if pressed down upon them; secondly, when the lung has become compressed by the effusion of air, serum, or blood into the pleural sac. In the latter cases, tight bandaging of the chest will cause great distress; for, the lung on the injured side being already rendered useless, or nearly so, by the compression, respiration is altogether carried on by the lung on the uninjured side. If the chest be uniformly or tightly compressed, the use of this lung also is interfered with to such an extent that a semi-asphyxial condition may ensue.

In a *penetrating wound of the chest by a sharp cutting instrument*, if it be a clean puncture, an attempt should be made to close it in such a way as to obtain union by the first intention. For this purpose some form of antiseptic treatment should always be adopted. The skin around the wound must be cleaned with some efficient antiseptic solution, such as carbolic acid lotion (1 in 20), and the wound itself may be wiped out by means of a sponge soaked in the same solution and held in a pair of forceps. If the wound be large the edges may then be brought together by sutures; if it be small and not gaping, these are not required. The surface must next be covered with an antiseptic dressing. In the absence of an antiseptic dressing the wound may be closed by lint and collodion, or a piece of lint may be soaked in the blood and allowed to dry upon it. If the wound be thus closed the patient must be carefully examined daily for effusion into the pleura, and the temperature must be watched. Should there be increasing dulness, with a high temperature, the fluid must be removed by means of the aspirator, and examined. Should it be turbid or purulent a free vent must at once be provided for it, either by opening up the original wound, or by making a new one at the most convenient spot.

Should the wound be large and deep, with blood and air issuing freely through it from the injured lung, it should not be completely closed, otherwise pneumothorax and emphysema, or hæmothorax will certainly occur. It may be cleaned with an antiseptic solution, and partly closed by sutures, a large drainage-tube inserted, and an antiseptic dressing applied, or in the absence of antiseptics it may be covered with a piece of oiled lint. The patient should be laid on the wounded side, and the wall of the chest may be fixed by long broad strips of plaster applied to the injured side only, an aperture being left between the strips opposite the wound. Mouat states that excellent results have followed this plan of treatment in military practice.

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these writers, whenever this rises and the cough or hæmoptysis returns, recourse should be had to the lancet. In the Crimean campaign, Macleod states that "those cases did best in which early, active, and repeated bleedings were had recourse to." In the official Report of the Medical and Surgical History of the War in the Crimea, venesection is advocated with equal decision as a means of arresting hæmoptysis. The writer states: "When hæmoptysis to any considerable or dangerous extent is present, venesection for the rapid induction of syncope seems not only allowable, but seems to afford the only chance of safety, and may even require to be repeated." However paradoxical or even irrational it might at first sight appear to endeavour to restrain one hæmorrhage by establishing another, yet the practice seemed established as the result of experience; and its good effects could be explained by the sudden induction of syncope giving time for the sealing up of the pulmonary vessels by coagulation of blood within them. But although this was the practice up to a comparatively recent period, the views of military Surgeons on this point seem now to have undergone a complete change; and the experience derived from the great Civil War in America and from the Maori war in New Zealand, has led to the promulgation of different doctrines and the adoption of a different line of practice. In the American war, venesection appears to have been generally abandoned, while reliance was placed on rest, cold, and opium for the arrest of hæmorrhage; and this practice is said to have been generally satisfactory. In New Zealand, Mouat states that bleeding was almost entirely discarded. Longmore says that, if the patient should survive, the loss of blood by venesection seems to interrupt the reparative measures adopted by nature.

If extravasation of blood into the pleura be going on, its further effusion must, if possible, be arrested by the same means. Should the hæmorrhage continue notwithstanding the employment of the means indicated, Guthrie advises that the wound should be closed, so that the blood which flows into the pleural sac may, by accumulating in this, compress the lung, and thus arrest the further escape of blood from the wounded vessels; the patient at the same time should be made to lie on the injured side, in order to increase the pressure exercised upon the wounded organ. When the bleeding has been checked in this way, the blood must be removed as early as possible from the pleural sac; for, if it be allowed to remain, it will in most cases decompose, the putrefactive ferment having found its way in before the wound was closed. Death then may take place from absorption of the products of putrefaction, or should the patient escape this, suppurative pleurisy inevitably follows. To prevent this, the pleura must be tapped with a large aspirator-needle on the fourth or fifth day, or earlier if the temperature be very high. Should it be found that the blood is free from putrefaction, the extravasation is best removed by repeated aspirations, care being taken not to remove too much at one time, lest by causing a forcible expansion of the lung the hæmorrhage may be started again. If the fluid withdrawn is decomposing, a free opening must be made either from the original wound, or at the most convenient spot, and a large drainage-tube inserted. The after-treatment will be the same as for septic empyema.

During the American war various drugs were made use of, with the intention of aiding the arrest of hæmorrhage, amongst them being tartarated antimony, llic and tannic acids, and acetate of lead; but their effects do not

seem to have been such as to justify any reliance being placed upon them. In the Crimean war the Russian Surgeons administered digitalis; but according to the present views of the action of that drug, its use could be productive only of harm.

Pleurisy and Empyema.—If the patient survive to the third day, the danger to be apprehended is no longer from hæmorrhage, but from inflammation and suppuration in the cavity of the pleura, consequent upon the decomposition of the discharges accumulated in that cavity. This is in some cases complicated by inflammation of the lung spreading from the track of the wound. Military Surgeons formerly recommended venesection as a means both of preventing and of reducing inflammation. Since, however, the part played by the decomposition of the discharges in the pleural cavity has become fully recognised, much more importance has been attached to draining and cleaning the pleural cavity than to any efforts by means of blood-letting or drugs to subdue the local inflammation and constitutional disturbance. Possibly, in civil practice, if a case were met with in which the inflammation was confined to the lung substance, and attended with much dyspnœa in a healthy young subject, some relief might be given by venesection; but such a condition is so rare that it may practically be excluded from our consideration. When the dyspnœa arises from pleuritic effusion, bleeding must necessarily be useless, and in fact could only be injurious by still further weakening the powers of the patient. The inflammation must be combated by removing its cause as far as possible.

In the first place every effort should be made to prevent the occurrence of decomposition, either of extravasated blood or of inflammatory exudation in the cavity of the pleura by the adoption of some efficient method of antiseptic treatment. Should these endeavours fail, and the pleura become distended with decomposing discharges, the freest possible drainage must be provided by enlarging the original wound, and if necessary, making a counter-opening at the most convenient spot. All counter-openings must be made on a probe passed from the original wound and made to project between two ribs, as the relations of the walls and contents of the cavity are often much altered in these cases, and unless a guide is obtained in this way, either the diaphragm or the lung might be accidentally wounded. Large drainage-tubes should be inserted at the wound and the counter-opening if one has been made. If any difficulty is experienced in doing this, a piece of rib may be cut away. If the discharges are offensive, the cavity of the pleura must be cautiously washed out with some antiseptic solution. König reports that he obtained very good results in the Franco-German war by using a strong solution of chloride of zinc.

It will always be necessary in these cases to support the patient's strength by abundant liquid nourishment and stimulants when they are obtainable. Pain and cough may often be relieved by opium.

If any extraneous body, such as a bullet, a piece of wadding or of clothing, have penetrated too deeply into the chest to be readily extracted through the external wound, it would not be safe to make incisions or exploratory researches, with a view to extracting it; for, though its presence would increase the patient's danger, yet attempts at extraction would not only add to this, but would in all probability be fatal. In many cases, bodies so lodged become surrounded by pus, are loosened, and eventually are spat up, or appear at the external wound. In other cases, they remain permanently fixed in the chest,

becoming enveloped in a cyst, and so remaining for years, without producing irritation. In this way, Hennen states, a bullet has been lodged in the chest for upwards of twenty years; and Vidal mentions the case of a man who lived for fifteen years with the broken end of a foil in his chest, which, after death, was found sticking in the vertebræ, and stretching across to one of the ribs.

The *Treatment of Emphysema and Pneumothorax* consists of little in addition to what is called for by the wounded lung. In many cases, indeed, the air becomes absorbed in three or four days without the necessity for any local interference. If, however, the pneumothorax interfere with respiration by pressure on the opposite lung, the external wound, if any exist, must be freely opened, and punctures may be necessary to give exit to the air in the areolar tissue. If no wound exists the pleura must be tapped as for fluid, and, if necessary, the cannula must be left in. I doubt whether emphysema alone can ever prove fatal.

HERNIA OF THE LUNG, OR PNEUMOCELE.—This is an extremely rare condition. It consists in the protrusion of a portion of lung at some part of the thoracic wall. The hernia may occur through a perforating wound of the chest, beneath the cicatrix after the wound has healed, and in rare cases without any external wound. The protrusion of a portion of the lung through a wound of the chest is most likely to occur when the pleura is freely opened but the lung itself not injured. It has been seen more often in wounds of the front of the chest than in those behind, and especially in wounds situated over one border of the lung. Malgaigne has ascribed the occurrence of the hernia to air forcibly driven from the sound lung into that of the injured side, during a violent expiratory effort with closed glottis. Peyrot points out that if the lung itself be so much wounded that bronchial tubes are opened, the air thus driven into the lung will readily escape into the pleural cavity, and thus the necessary conditions for the production of a hernia are absent. If the wound be free the protruded lung may return on pressure or during inspiration. If left unreturned, it soon becomes livid and gangrenous; in these circumstances it may be removed by the knife or ligature.

As an instance of hernia of the lung beneath a cicatrix I may briefly relate a case which I saw in 1839 in Velpeau's wards at La Charité.

A man twenty-nine years of age, left-handed, received in a duel a sword-wound at the inner side of, and a little below the left nipple; he lost a considerable quantity of blood, but did not spit up any. The wound healed in about a fortnight, shortly after which he noticed the tumour, for which he was admitted three months and a half after the receipt of the injury. On examination, an indurated cicatrix about half an inch in length was found a little below, and to the inner side of, the left nipple. On expiring or coughing, a soft tumour of about the size of an egg appeared immediately underneath the cicatrix, which it raised up; it subsided under pressure, or when the patient ceased to expire or to cough; and its protrusion could be prevented by pressing the finger firmly on the part where it appeared, when a depression was felt in the intercostal muscles. If the fingers were slid obliquely over the tumour, it yielded a fine and distinct crepitation, exactly resembling that produced by compressing a healthy lung, and the spongy feel of the organ could be recognized. On applying the ear, a fine crackling and rubbing sound was distinctly perceived; the tumour was resonant on percussion. The portion of

protruded lung did not appear to re-enter the chest on inspiration, but was firmly fixed in its new situation. No treatment was adopted in the case, nor does any appear admissible in similar instances.

Hernia of the lung has been known to occur from fractured ribs without any wound, and even from violent straining during labour.

I have seen a case in a man who gained his livelihood by playing the cornet. In these cases it is probable that, the intercostal muscles and costal pleura having been divided or ruptured by the efforts of the patient and not having united afterwards, the lung has, during expiration, gradually insinuated itself into the aperture so formed until at last the hernial tumour has appeared. This protrusion may take place at any part of the thoracic parietes; thus Velpeau observed it in the supraclavicular region of a girl; but most commonly it occurs on one or other side of the chest. The tumour may attain a large size; I have heard Velpeau state that he had seen one half as large as the head. It does not appear to shorten life.

The only affection with which a hernia of the lung can be confounded is a circumscribed empyema which is making its way through the walls of the chest. Here, however, the dulness on percussion, and the absence of respiratory murmur and of crackling under the fingers, will readily enable the Surgeon to make the diagnosis.

WOUNDS OF THE HEART AND LARGE VESSELS.

Wounds of the Pericardium.—The pericardium may be wounded with or without penetration of the chest, and with or without injury of the heart. Without wound of the chest-wall, it may be lacerated by a severe contusion; with penetration of the chest-wall, it may be wounded by a stab or by gunshot.

Laceration of the Pericardium may take place from a severe blow on the chest. I have seen the membrane split longitudinally for two or three inches, from contusion received in a fall.

The **Pericardium may be wounded** by a stab without the heart being injured. Thus I have seen a wound of the pericardium in a young man, inflicted by his sweetheart with a sharp-pointed pair of embroidery scissors.

The pericardium may be bruised or cut by an oblique gunshot wound without damage to the heart. This I have seen happen from a pistol-bullet penetrating the chest obliquely.

In injuries such as these, collapse to a greater or less extent is always met with. This is followed by inflammation; the ordinary auscultatory signs of pericarditis followed by effusion, such as friction, with extended dulness on percussion, become perceptible; and there are intense thoracic oppression, dyspnœa, and restlessness, with pallor and a small rapid pulse.

In some cases of wound of the pericardium, with a superficial injury to the heart, one of the *coronary vessels* may be divided, and blood effused into the sac. In these cases the interposition of the layer of blood causes the heart sounds to be weak and remote, the impulse of the apex to be indistinct or imperceptible, and the cardiac dulness to be widely diffused.

The *Prognosis* of cases of injury of the pericardium is necessarily very unfavourable. The heart may become choked by the intrapericardial extravasation of blood or the inflammatory effusion.

The *Treatment* of these cases of wound of the pericardium should be conducted as far as possible on antiseptic principles. In cases of a punctured wound, should the external opening close, and the pericardium become distended with effusion to such an extent as to embarrass the action of the heart and threaten to prove fatal, the fluid must be removed by means of the aspirator. (See Tapping the Pericardium, Vol. II.) The general treatment must be conducted on those ordinary medical principles that guide us in the management of pericarditis arising from other causes.

Wounds of the Heart.—The heart may receive a wound which does not penetrate through the walls; or one or more of its cavities may be opened by the agent that inflicts the injury. Most commonly the wound is inflicted by stab or gunshot, and then generally no foreign body is lodged in the cardiac cavities or substance. But in some instances bullets, pieces of stick, needles, iron pins, and other substances, have been lodged and encysted in the walls of the ventricles.

In the vast majority of cases, wounds of the heart are immediately fatal, but they are not necessarily or invariably so. Much will depend on whether or not they penetrate into the cavities, and on the extent of the injury that the heart has sustained.

Non-Penetrating Wounds may be fatal at once from direct shock to the heart; or the patient may survive a few hours or days and then die of pericarditis; or he may recover and live for years, as in a case reported by West of Birmingham, in which the man lived for four and a half years. After death, evidences of extensive and severe pericarditis were found, and there was a linear cicatrix half an inch long in the anterior part of the right ventricle.

Penetrating Wounds of the Heart are almost invariably at once fatal from loss of blood and shock to the organ and system. This is especially the case if the cavities be largely opened, or much of the heart substance destroyed. But there are many exceptions to this general law of fatality. Jamain has collected 84 cases in which people lived for considerable periods after having received a wound of the heart. Of these, in 35 cases the right ventricle was wounded, and the sufferers lived from four and a half hours to twenty-three days. In 19 cases the injury was to the left ventricle; and of these life was prolonged to periods varying from half an hour, in two cases, to six months in one instance. Both ventricles were wounded in five cases in patients who lived from one hour to nine and a half months; the right auricle in seven cases, the patients living from seven hours to twenty days; the left auricle in two cases, in which the patients lived respectively one and two days. In many cases, the patient has been known to walk or run some considerable distance after the receipt of the injury. Ollivier and Samson have collected 29 cases of penetrating wounds of the heart which did not prove fatal in the first forty-eight hours after the receipt of the injury. On analysing these, it would appear that the rapidity of death depends greatly on the direction of the wound and the part of the organ injured. When the wound is parallel to the axis of the heart, it is not so speedily fatal as when in a transverse direction, and wounds of the auricle are more immediately followed by death than those of the ventricle; the irregular contraction of the different planes of muscular fibre that enter into the formation of the wall of the ventricle tending to obstruct the free passage of the blood through the wound, and perhaps to close it entirely. The size

of the wound, however, will necessarily influence the result more materially than its direction. Not only may a person live a considerable time after having received a penetrating wound of the heart, but there are many cases on record in which life has been prolonged even though a foreign body was lodged in the cavities or substance of the organ. Thus Ferrus relates the case of a man who lived for twenty days with a skewer traversing the heart from side to side; and Roux that of a man who lived twenty-one days with a portion of a file, with which he had stabbed himself, in the wall of the left ventricle. Davis and Stewart found a piece of wood, three inches long, in the right ventricle of a boy, who lived five weeks after the accident; Carnochan relates a case in which the wounded man survived eleven days with a bullet deeply lodged in the substance of the apex of the heart; and Latour records the case of a soldier who lived for six years after being wounded by a musket-ball in the side, and in the right ventricle of whose heart the bullet was found lodged, lying against the septum.

The part of the heart that has been injured may be determined by attention to the situation of the wound and the direction it takes, for the situation of the different cavities of the heart in relation to the superficial structures is constant. Thus, a stab below the fifth rib, about one inch to the sternal side of the nipple, and two inches below it, would wound the apex of the heart; a stab through the second intercostal space close to the right side of the sternum would wound the most prominent part of the ascending aorta after passing through the lung. One through the third to the fifth intercostal spaces to the right of the sternum would wound the right auricle. The pulmonary artery would be reached by a thrust through the third rib on the left side at its junction with the sternum. The statistics collected by Fischer, Jamain, West, and others, show that the right ventricle is most commonly wounded.

There are instances on record in which a ball has entered the chest and caused a laceration of the heart substance without penetrating the pericardium, which escaped in consequence of its firmness and fibrous character. Again, as has already been stated, the pericardium alone may be injured: Fischer has collected 51 such cases.

The **Symptoms** of a wound of the heart, when immediately fatal, are as follows. The person struck springs up convulsively, or falls suddenly prostrate; sometimes with, sometimes without, a sudden sharp shriek. Death results from hæmorrhage, which will be profuse, the blood passing out beyond the pericardium, if the wound be large and that membrane be widely opened; or into the pericardium, preventing the action of the heart by compression, if the wound be small. In either case, death is hastened by collapse arising from shock to the heart itself, and to the system at large from the wound of so important an organ.

If the wound be small and death be not immediate, there are evidences of great shock in the intense depression of vital power, the pallid and anxious countenance, and the relaxation of the limbs. The action of the heart itself is tumultuous, weak, and irregular; the pulse is scarcely perceptible; the breathing is extremely embarrassed. If the patient survive a few days, these symptoms partially and intermittingly subside, and the ordinary signs of pericarditis come on—friction, gradually disappearing more or less completely

as the pericardium becomes distended with fluid, when there will be increased dulness on percussion, with a weak impulse and elevation of the heart's apex. By auscultation the heart sounds will be found to be feeble and muffled, especially at the apex. To these symptoms may possibly be added evidences of endocardial inflammation. Of these consecutive inflammatory complications and of their consequences the patient will most probably die, though perhaps at a remote period and after prolonged suffering.

Rupture of the Heart from External Violence, without penetrating wound of the chest, is not of frequent occurrence. Gamgee has, however, collected 22 published cases of this accident. On analysing these he finds that, in at least one half of the cases, the pericardium was intact; 12 of the ruptures were on the right, 10 on the left side. The right ventricle was ruptured in 8, and the left in 3 cases; whereas the left auricle was torn in 7, and the right only in 4 instances. Death is usually almost instantaneous, though there are instances on record in which the patient made some exertion after the rupture had taken place, and even lived for several hours. In a case of rupture of the right auricle recorded by Rust, the patient survived fourteen hours. In most of the recorded cases, the injury occasioning the rupture was directly applied to the region of the heart. But instances are not wanting in which this organ has been found ruptured through one or both ventricles or in one of the auricles, without any evidence of direct injury in the cardiac region—the patient having fallen upon his head or shoulders, or having merely been thrown forcibly to the ground with serious injury to the lower extremities. In some of these cases, there is reason to believe that the rupture was produced by the violence of the contractions of the heart, under the influence of great mental emotion or fear. The only case that has occurred in my practice was that of a man brought into the Hospital dead, having fallen from the top of a cart on to his right shoulder. On examination, the liver was found extensively torn, in fact smashed, and the pericardium was distended with blood—there being a triangular ragged aperture at the anterior part of the left auricular appendage, through which it had escaped.

Wounds of the Aorta and Vena Cava are usually as immediately fatal as those of the heart itself. In this respect, they resemble wounds of the auricles rather than those of the ventricles. Heil has, however, recorded a case in which the patient lived for a twelvemonth, after receiving a stab that penetrated the ascending aorta.

Wound of the Thoracic Duct is very rare. It has occurred during an attempt to ligature the first part of the left subclavian artery, in removal of tumours, and in stabs above the clavicle or in the chest. The chief symptom is a constant draining away of chyle. The injury has been almost invariably fatal. Bradley has collected and published the following six cases which well illustrate the characters of the injury:—

"Hoffmann's first case was that of a woman wounded through the left side with a knife. Following the wound there was a copious discharge of spontaneously coagulating fluid, which was observed to be milky during digestion, and clear while the patient was fasting. In his second case, the escape of chyle followed the opening of an abscess of the posterior mediastinum. Monro relates a case where the thoracic duct was wounded by a stab; the lymph escaped externally and also into the pleural cavity, interfering with the heart's action. Guiffort's case is of a similar nature. Bonnet gives the history of a

Baron Heinden, who was wounded in battle by a bullet, which escaped beneath the left scapula. From this wound there gradually began to flow an excessive quantity of lymph." In Quincke's case, "the pleural cavity became so full of extravasated lymph that paracentesis had to be performed to prevent suffocation, from which, indeed, the patient eventually died." Krabbel subsequently recorded the case of a boy in whom the duct was completely torn across by a fracture of the ninth dorsal vertebra, from the passage of an empty coal-truck over the back. Death occurred on the fifth day, and the right pleural cavity was found to be distended with chyle. A doubtful case also occurred to Kirchner, in a girl aged 9, who, fourteen days before, had run violently against a "window parapet." A litre of chyle was withdrawn by aspiration from the right pleura, and the patient recovered.

Keen, of Philadelphia, has collected four cases, including one of his own, in which the thoracic duct was probably wounded during operations in the neck. In Cheever's case the patient died of shock thirty-six hours after the operation. In Boegehold's case the wound was plugged and the patient recovered. In Phelps's case the point from which the fluid escaped in large quantities was ligatured seven days after the operation, and the patient made an excellent recovery. In the case operated upon by Keen the wound in the duct was closed with fine silk, and recovery followed.

CHAPTER XXIX.

INJURIES OF THE ABDOMEN AND PELVIS.

INJURIES OF THE ABDOMEN AND ABDOMINAL VISCERA.

INJURIES of the abdomen may be divided into Contusions, with or without Rupture of Internal Organs; Non-penetrating Wounds; and Penetrating Wounds, either uncomplicated, or conjoined with Injury or Protrusion of some of the Organs contained in this cavity.

CONTUSIONS OF THE ABDOMEN derive their great importance from the frequency with which the various organs contained within the abdominal cavity are injured.

Contusions of the Abdominal Walls from blows or kicks usually terminate without serious inconvenience. In some cases, however, the muscles of the abdominal wall may be ruptured subcutaneously. A man was admitted under my care into the Hospital who had received a blow from the buffer of a railway carriage upon his abdomen. He complained of great pain at one spot; and, on examination after death, we found the rectus muscle torn across without injury either to the integuments or the peritoneum. If the patient live, an injury of this kind is apt to be followed by a ventral hernia. Occasionally the contusion is followed by abscess in the abdominal wall, which has a tendency to extend widely between the muscular planes. The abscesses should be opened early, lest they burst into the peritoneal cavity and occasion fatal inflammation.

Contusions of the Abdomen with Injury of some of the Viscera commonly result from blows and kicks, the passage of a cart-wheel over the abdomen, or a squeeze of the body between the buffers of two railway carriages. These "*buffer accidents*" are of common occurrence in hospital practice, the usual victims being railway porters, who, in trying to pass between carriages in motion, are caught and squeezed between the buffers. In these cases the most fearful internal injuries occur, without any external wound. A man was admitted under my care into University College Hospital, in whom the liver, stomach, spleen, and kidneys were crushed and torn; the heart was ecchymosed on its surface, and one of the lungs was lacerated, without any rupture of the skin or fracture of the ribs. The particular organ injured depends on the situation of the blow. The organ that is most frequently crushed in this way is the liver, owing to its large size and the unyielding nature and ready lacerability of its structure; the other solid organs, such as the spleen and kidneys, do not suffer so frequently. Among the hollow organs, the stomach most commonly suffers, and it is especially likely to do so if struck while distended by food. Any portion of the intestinal canal may be lacerated. I have seen the duodenum, the ileum,

the jejunum, and the large intestine ruptured in different cases; the mesentery likewise may be lacerated, and the spermatic cord torn across.

The **Symptoms** of a severe contusion of the abdomen necessarily vary according to the nature of the accident and the extent of the damage to the abdominal viscera. The injury is usually followed by more or less profound shock, which may of itself prove fatal, though there be but little apparent internal mischief; thus, I have seen a man die collapsed eight hours after a buffer accident, in whom no injury was found except a small rupture of the mesentery, attended with but very slight extravasation of blood.

The severity of the shock, amounting often to prolonged and complete collapse, is one of the most remarkable phenomena attending these injuries. It is difficult to account for it, except on the supposition that it is due to wound or concussion of the sympathetic nerves and the large abdominal ganglia. To whatever cause it may be referred, it is certain that it is greater than that which follows a corresponding injury, unattended with loss of blood, of any other part of the body except the central portions of the cerebro-spinal nervous system. So far as my experience goes, I would say that the shock is most severe in injuries of and about the stomach, probably from damage to the solar plexus. It has been pointed out that the persistence, rather than the severity, of the shock, is an indication of severe internal injury.

In many cases of abdominal contusion, the patient presents symptoms characteristic of internal hæmorrhage, and in certain instances, the presence of an extensive effusion of blood is revealed by dulness in the flanks, shifting with change of posture. The most usual source of severe abdominal hæmorrhage is a ruptured liver or spleen.

Vomiting is a very variable symptom after abdominal injuries, and is of little value as a means of diagnosis. It frequently occurs in cases followed by recovery, and on the other hand it may be absent throughout in cases of rupture of the stomach or intestines. At a later stage, repeated bilious vomiting may be a symptom of peritonitis. Bloody vomiting may be, as we shall see, a symptom of rupture of the stomach.

A careful examination of the abdomen should be made, and the presence of bruising or abrasion of the skin may be of value in forming a conclusion as to the probable nature of the injury. Thus, if in a case presenting the general symptoms of internal hæmorrhage there be marked bruising in the right hypochondrium, the diagnosis of rupture of the liver is justified. The possible presence of dulness in the flanks as the result of intraperitoneal hæmorrhage has already been mentioned. The presence of free gas in the peritoneal cavity may be shown by general tympanites and especially by a resonant note over the liver. This symptom can only be due to rupture of some part of the digestive tract. Careful palpation of the abdomen may, if the patient be not too deeply collapsed, elicit marked tenderness definitely localised to one spot; this may be of value in determining the probable seat of an internal injury. In every case of severe abdominal contusion it is the duty of the Surgeon to pass a catheter; he may thus detect evidences of rupture of the bladder (p. 893), whilst the presence of blood in the urine may be the result of bruising or laceration of the kidney.

It has already been stated that intense shock may follow an abdominal contusion unattended with any serious lesion of the viscera. Although intense, the shock is in such cases usually of short duration, and severe internal injury

may be suspected if it be persistent. It has further been pointed out that the suspicion is increased if persistent shock be associated with localised abdominal pain and tenderness.

The patient who has survived the more immediate effects of the accident is still liable to the occurrence of peritonitis, which is not necessarily the result of rupture of one of the viscera.

Having thus briefly considered the chief points to be observed in a case of severe contusion of the abdomen, it remains to describe in greater detail the symptoms which result from injury of the principal abdominal viscera.

If the **Liver** has been ruptured, pain over the region of that organ, dulness on percussion from extravasated blood, and great collapse, followed, if the patient live, by diffuse peritonitis, bilious vomiting, white stools, and jaundice, will, with sufficient precision, indicate the true nature of the injury. Bernard has further shown that contusions of the liver may be followed by the appearance of sugar in the urine.

Rupture of the liver is by no means always speedily or even necessarily fatal. It may be, and usually is so, from extravasation of blood or of bile; but if neither of these be largely poured out, the patient may live for some considerable time, though he may eventually succumb to peritonitis. A man was once admitted under my care into University College Hospital, who had been crushed between the buffers of two railway carriages. He was collapsed and apparently moribund, but rallied in a few hours. Two days after the accident, great pain and tenderness in the right hypochrondrium were complained of, and dulness on percussion was found to extend as low as the umbilicus. He became jaundiced, and there were symptoms of peritonitis; these were followed by great swelling of the abdomen, which became tympanitic; the peritonitis continued, and symptoms of intestinal obstruction came on, the dulness increasing, with fluctuation in the flanks. He died on the sixteenth day after the accident, and on examination no less than 240 ounces of bilious fluid, mixed with flakes of lymph, were found in the abdominal cavity; the obstruction of the bowels being dependent on the pressure of this effusion, and on the matting together of the intestines by lymph. There was a large rent in the thick border of the liver, which was beginning to cicatrize.

The following is an example in which recovery took place. A man, about forty years of age, fell from a scaffold to the ground. In falling, he struck violently against a beam, injuring his abdomen on the right side. He was brought to the Hospital in a state of collapse, from which he slowly rallied. There was no injury but that of the abdomen, of which he complained much, more particularly over the region of the liver, which was very tense. Peritonitis speedily set in, with great tympanitic distension of the belly, vomiting of bilious matter, and the passage of colourless stools. These symptoms continued many days, and the man became jaundiced. As the tympanites subsided, it was found that there was dulness on percussion in both flanks, and that the fluid, which was evidently extravasated into the peritoneal cavity, rose to a level with the umbilicus when he lay on his left side, which he did habitually. He was treated with opium, and put on a very mild unstimulating diet. He gradually but slowly recovered, the vomiting becoming less frequent, and eventually ceasing, and the fluid in the abdomen being slowly absorbed, bile at the same time appearing in the motions; but the tenderness over the

region of the liver continued up to the time at which he left the Hospital, nearly two months after the accident. In this case the long and severe collapse, the seat of pain and injury, the peritonitis, the bilious vomitings, and the white stools, all pointed to serious injury of the liver; and rapid intra-abdominal extravasation could be accounted for only by rupture of that organ.

If the **Spleen** has been lacerated, there will be severe shock, accompanied by signs of internal hæmorrhage; coldness and pallor of the surface, a small and feeble pulse, anxiety of countenance, and great depression of the vital powers, with pain at the seat of injury, and dulness on percussion from extravasated blood. These symptoms usually terminate rapidly in death. Rupture of the spleen is specially liable to occur from slight blows when that organ is enlarged as the result of exposure to a malarious climate.

If the **Kidneys** are injured, there will often be a frequent desire to pass urine, and that fluid will be tinged with blood, often to a considerable extent. If the ureter become plugged by a clot there may be severe renal colic, the pain shooting down to the testicle and thigh. Sometimes the bladder becomes distended with coagulated blood. After the discharge of blood ceases, the urine will become albuminous, and may continue so for a great length of time. On examining such albuminous urine under the microscope, it will generally be found to contain a few blood-corpuscles, and possibly some tube-casts, which at first, perhaps, contain blood-corpuscles, and later on become granular. Pus and mucus, with epithelium-cells from the pelvis of the kidney, and occasionally renal epithelium, may be met with later on, showing the existence of inflammation in the kidney. It is an important practical fact, so far as my experience goes, that albumen never appears in the urine as the result of renal injury, unless it has been preceded by blood. The absence of blood from the urine must not, however, be taken as an indication that the kidney is not injured: it may be so disorganized as to be totally incapable of secreting, or the ureter being torn across no bloody urine finds its way into the bladder. A man was admitted into the Hospital under my care for a buffer injury of the back; he passed urine untinged with blood, but after death his right kidney was found completely smashed by the blow, and there was an extensive extravasation of blood in the fat around it; here it was evident that the disorganisation was so sudden and complete that no urine could find its way into the bladder. In another case, in consequence of a fall from a window, an elderly man died in the course of an hour, having struck his back and sustained several fractures of the limbs. The left kidney was ruptured in a starred manner, with extensive extravasation of blood into the tissues around it, but there was not a tinge of blood in the urine which was retained in the bladder.

Rupture of the kidney is by no means necessarily fatal. Patients have lived after exhibiting all the signs of it—the passing of bloody urine, and the presence of circumscribed peritonitis; and, when death has occurred at a later period, cicatrices have been detected in the organ. A patient was admitted under my care into University College Hospital for a severe blow upon the back from the buffer of a railway carriage, followed by hæmaturia and other symptoms of renal injury; on his death from pneumonia nine weeks after the accident, an extravasation of blood, with the marks of recent cicatrization, was found in the left kidney.

If the **Ureter** or **Pelvis of the Kidney** is ruptured the urine may accumulate in the loose tissue around the kidney. A large fluctuating tumour is thus gradually formed in the injured side of the abdomen, bulging in the loin and filling the interval between the iliac fossa and the ribs. The absence of acute inflammation in such cases is worthy of note, the fluid gradually becoming encysted by consolidation of the surrounding tissues. The presence of blood in the urine may or may not be detected after the accident. In one recorded case of this nature as much as six pints of urine were removed by tapping at one sitting. On examination after death, which occurred in the tenth week from the accident, a large cyst was found behind the peritoneum, communicating with the pelvis of the kidney. Two cases of this kind have occurred in University College Hospital. In the one the patient, a child aged 3 years, under the care of Barker, was run over by a cab. The right side was bruised, and a few small clots were passed in the urine. About three weeks later a large fluctuating tumour was found reaching from the iliac fossa to the ribs. Aspiration showed that it contained urine. As repeated aspiration failed to give any relief, a drainage tube was inserted, with the result of establishing a fistula. Finally, as the only means of cure, the kidney was removed. The child recovered from the operation, but died subsequently of general tuberculosis. The kidney and pelvis were found to be uninjured. The second case was under the care of Godlee, and similar treatment was successfully adopted.

Another possible result of rupture of the ureter is the rapid development of hydronephrosis. In a case of this kind under the care of Pickering Pick at the Victoria Hospital for Children, the boy had fallen on the edge of a kerbstone. The accident was followed by blood in the urine and the rapid development of a tense fluid swelling in the left loin. Urine was several times withdrawn by aspiration, and for the cure of the fistula which resulted from drainage, the dilated kidney was finally excised. It is interesting to note that in two cases apparently of this nature recorded by Goodhart, spontaneous cure gradually took place after an interval of many months.

When the **Stomach** is ruptured the nature of the accident is usually revealed by bloody vomiting, with pain in the region of the stomach, and the most profound shock. These signs, however, do not occur in all cases. A man was admitted to the Hospital under my care, whose abdomen had been squeezed between a cart-wheel and a lamp-post; during the five hours that he lived he vomited several times, bringing up a meal which he had taken immediately before the accident. In the vomited matters there was no blood to be seen; but after death it was found that not only the liver and spleen were ruptured, but the stomach was torn almost across near the pylorus.

Rupture of the **Intestine** is much more common than that of the stomach. It may occur at any part, but is most commonly met with in the duodenum or at the junction of the duodenum and jejunum. The frequency with which the duodenum is ruptured is due partly to its position, and partly to its fixity. The third part of the duodenum crosses the spine in front of the second lumbar vertebra, or about one inch above the umbilicus, and thus receives no protection from the costal cartilages. In this part of its course it is uncovered by peritoneum, and is consequently fixed so firmly that it receives the full force of any violent pressure, being unable to slip away from beneath it, as do those parts of the intestine which are completely covered by peritoneum,

and attached to a loose mesentery. When the force is applied in an oblique direction from right to left, rupture occasionally takes place at the junction of the movable jejunum with the fixed duodenum. Rupture of the duodenum may therefore occur with or without injury to the peritoneum. Rupture of the gut into the peritoneal cavity is indicated by intense pain in the belly with severe shock. Free gas in the peritoneal cavity may sometimes be recognized by tympanitic resonance in front of the liver. Peritonitis speedily sets in, with vomiting, at first bilious, but soon becoming dark-coloured or almost black. The abdomen becomes tympanitic and tensely distended, with gradually increasing dulness in each flank. The belly is acutely tender, and the patient lies on his back with his knees drawn up. These injuries are extremely fatal; in fact if the aperture in the gut be of sufficient size to allow of the escape of its contents into the peritoneal cavity, death almost inevitably results. Rupture of the third part of the duodenum behind the peritoneum is accompanied by much less clearly marked symptoms; there are pain and tenderness, and possibly vomiting of blood. If the patient survive sufficiently long he may pass a motion blackened by altered blood. Death takes place in those cases usually from diffuse suppuration spreading in the loose subperitoneal tissue downwards in front of the kidneys or even to the iliac fossæ, in consequence of which peritonitis with effusion is often set up.

An occasional symptom of rupture of the intestine is **Emphysema of the Abdominal Wall,** and subsequently of the trunk generally, from the escape of gas from the wounded intestine into the subperitoneal areolar tissue, and thence into the more superficial planes. When this takes place, the same doughy, puffy, inelastic, crepitating swelling of the subcutaneous areolar tissue, that is met with in thoracic emphysema, is observed. It usually commences in one or the other flank, and may then creep up towards the axilla, or into the anterior abdominal wall.

As a diagnostic sign, this form of emphysema is valuable in those cases in which the intestines have been injured, either without any wound of the abdominal parietes, or, if there be wound, without protrusion of the injured portion of gut. In two of the cases in which I have observed it, this condition was the only positive sign of intestinal injury. In one case, the third part of the duodenum had been ruptured where uncovered by peritoneum, by a buffer accident; and, in the other the rectum and meso-rectum had been traversed by a pistol-ball. In both these cases the emphysema was extensive, the gas having passed directly into the subperitoneal areolar tissue. In other cases it may in the first instance pass into the cavity of the abdomen, and render that tympanitic, and then, as in thoracic emphysema after pneumothorax, escape into the areolar tissue at the edges of the wound. In a case under my observation, it occurred after tapping of the bladder through the rectum. The gas escaped, after the removal of the cannula on the sixth day, through the small aperture in the walls of the gut into the subperitoneal areolar tissue of the pelvis, and thence, through the sciatic notches, down the posterior and outer parts of the thighs and the flanks.

The diagnosis of abdominal emphysema requires to be made from thoracic emphysema, and from putrefactive infiltration of air into the areolar tissue. In the first case, this may readily be effected by the absence of any signs of thoracic injury, and by the situation of the emphysema in the posterior or lateral abdominal wall, or around the lips of a wound. From putrefactive

infiltration with gas, abdominal emphysema is distinguished by the cause, and by the absence of diffuse inflammation of the areolar tissue.

There can be little doubt that more or less extensive bruising of the intestine occurs in many cases of abdominal contusion which end in recovery. It occasionally happens, however, that the damage to the wall of the bowel is followed by sloughing. As the result of the separation of the slough the intestinal contents may escape into the peritoneal cavity, with the production of symptoms similar to those which occur when the gut is ruptured at the time of the injury. If, however, the affected portion of bowel become surrounded by adhesions the extravasation and consequent suppuration may be localized. Under these circumstances the abscess, if left untreated, may slowly point in the abdominal wall, and after it has burst a fæcal fistula may remain. Macewen has recorded the case of a boy in whom fatal perforation of the bowel occurred forty-seven days after he had been run over the abdomen. It thus behoves the Surgeon to be very careful in his treatment and guarded in his prognosis of every case of abdominal injury, and not to assert too hastily that the patient is out of danger.

In considering the question of the **Treatment** of a case of severe abdominal contusion the Surgeon has to choose between the adoption of expectant methods and the performance of an exploratory laparotomy. Every case must by judged upon its own merits, and the universal adoption of either line of treatment in all cases can only lead to disastrous results. The Surgeon who persistently avoids operative interference will be rewarded by finding conditions *post mortem* which a timely operation might have remedied; whilst on the other hand it is certain that the last chance of life will be taken from many patients, if the shock of an abdominal section be added to that of the injury itself. The presence of severe shock is suggestive of serious damage to one or more of the viscera, but reference has already been made to cases of death from this cause in which no gross visceral lesion has been found. Moreover, it is just in these cases that the dangerous condition of the patient, with cold extremities and flickering pulse, forbids operation, and it may be stated broadly that expectant treatment should be adopted if the only evidence of visceral lesion is the severity of the shock. The same rule must be followed even though there be vomiting and localized or general abdominal pain.

What then are the circumstances under which immediate laparotomy is indicated? First, if the general symptoms of internal hæmorrhage be present, with, it may be, the signs of an extensive effusion of blood into the peritoneal cavity, the Surgeon should open the abdomen, in the hope of arresting the bleeding from a ruptured liver or spleen, and for the removal of such blood as has already been effused. Secondly, if the occurrence of repeated bloody vomiting, with feeble pulse and the other signs of profound shock suggest rupture of the stomach. Thirdly, if the presence of free gas in the peritoneum, with general tympanites obscuring the hepatic dulness, indicates rupture of the bowel. Such a condition is necessarily fatal unless the opening in the bowel be closed, and the peritoneal cavity efficiently cleaned. Lastly, the signs of rupture of the urinary bladder are an indication for immediate laparotomy (p. 894). In certain cases of abdominal contusion operation may subsequently be required although there may have been no indication for its performance at the time of the injury. Thus it may at

times be thought advisable to make an exploratory incision if the shock persist and the seat of the supposed internal injury be suggested by local pain and tenderness. An operation should certainly be performed if the injury be followed by symptoms of peritonitis.

Ruptures of the stomach and intestine must be treated on the same lines as those laid down for the treatment of perforating wounds (p. 881); whilst a segment of hopelessly bruised intestine may be treated by resection. Croft has collected 14 cases in which laparotomy was performed for rupture of the intestine; of these 13 ended fatally. In the successful case, under his own care, the operation was performed $15\frac{1}{2}$ hours after the accident; there was a small rupture near the end of the jejunum, with fæcal extravasation and commencing peritonitis. The damaged piece of bowel was excised and the ends adjusted with Lembert's sutures.

In a second case under the same Surgeon a rupture of the ileum was treated by the formation of an artificial anus; death occurred four weeks later after a secondary operation for the cure of the artificial anus. Rupture of the liver has been successfully treated by suturing the rent in the organ, or, if this be impossible, by temporarily plugging the wound with strips of antiseptic gauze. The hæmorrhage from a ruptured spleen is so profuse, as usually to be rapidly fatal; if practicable the ruptured organ should be excised.

In the statistics compiled by MacCormac, Croft, and Morton of Philadelphia, are 20 cases in which laparotomy was performed for supposed rupture or contusion of the abdominal viscera without external wound. Of these only two recovered: one a case of rupture of the intestine under the care of Croft and already referred to; the other a case of extensive intraperitoneal hæmorrhage in which a branch of the pancreatico-duodenal artery was ligatured by McBurney. In 12 of the fatal cases the intestine was ruptured, and in 2 contused; in 2 cases the spleen was ruptured, in one of which the organ was excised; in one case there was rupture of the liver, and in one of the gall-bladder. The operation has, therefore, not as yet been attended with much success; but Croft's case, and the experience derived from stabs and gunshot wounds treated in the same way shows that in the case of a rupture of the small intestine it does give a chance of life. In ruptures of the solid viscera it is doubtful if much success is likely to attend operative interference. The great mortality of these injuries, if untreated, must however be borne in mind; thus Chavasse, quoted by MacCormac, estimates the mortality of rupture of the intestine without external wound at 96 per cent., whilst Edler gives the mortality of rupture of the liver as 85·8 per cent., and of the spleen, as 86·7 per cent.

The great difficulty in all these cases lies in making the diagnosis sufficiently early to be of any use. If it be delayed until septic peritonitis has set in, there is little hope for the patient, but even here laparotomy and drainage give the only conceivable chance of life.

In cases in which there are no indications for operation, the Surgeon must endeavour to induce reaction from shock by the means described in Chapter VIII. Opium may be administered freely and nourishment should be given entirely by the rectum. By these means the intestines are kept as completely at rest as possible, and recovery follows in some cases which at first seem hopeless. In cases of internal hæmorrhage, the intravenous injection of salt solution may be of service (p. 412).

In laceration or rupture of the kidney, operative interference is justified by three conditions: First, profuse and prolonged hæmorrhage, filling the bladder with clots, and threatening to prove fatal; secondly, if the symptoms indicate suppuration round the injured kidney; and, thirdly, if a large fluctuating tumour forms which on aspiration is found to be a collection of urine. (See Rupture of the Ureter.) In these cases the kidney may be exposed by a lumbar incision, and, if necessary, removed. (See Surgical Operations on the Kidney, Vol. II.)

Wounds of the Diaphragm may be occasioned by stabs or by gunshot injury; in rare cases by the fragment of a broken rib, without external wound. The lesion, though not in itself mortal, is usually complicated with so much visceral injury as to be followed by death. If the patient survive, the aperture may be closed by a cicatrix, to which the lung will probably adhere; and thus the separation between the cavities of the chest and abdomen will be maintained. Should this not happen, and the injury be on the left side, a hernial protrusion of some of the abdominal viscera may take place into the pleural cavity. (See Diaphragmatic Hernia.)

Wounds of the Abdomen.—**Wounds of the Abdominal Wall that do not penetrate the Peritoneal Cavity**, if uncomplicated with internal injury, usually do well, and require merely to be treated on ordinary principles. If they be incised, and so extensive as to require sutures, the stitches should be introduced deeply through the muscular and tendinous structures, and the parts injured must also be relaxed by careful attention to position. When they are the result of gunshot injury, they often suppurate extensively, and are slow in healing. The epigastric artery is occasionally divided, and this may give rise to free extravasation of blood into the sheath of the rectus; the wound must then be enlarged, if necessary, the extravasated blood cleaned out, and the artery secured.

Wounds that penetrate the Cavity of the Abdomen are of especial interest, on account of the frequency with which they are complicated with peritonitis, and with injury of the viscera. They may, for practical purposes, be divided into 1, those that are unaccompanied by protrusion of any of the viscera; and 2, those that are complicated by protrusion of one or more of the contents of the abdomen.

1. **Penetrating Wounds of the Abdomen, without Visceral Protrusion**, are often somewhat difficult to distinguish from simple wounds of the abdominal wall, though the escape of a small quantity of reddish serum may reveal the nature of the accident. The distinction can however in many cases be made only by carefully enlarging the superficial wound. Penetrating wounds of this nature are usually complicated with injury of the viscera, but it is a remarkable fact that the cavity of the abdomen may be perforated from front to back by bullet wounds or sword thrusts, without any signs of visceral injury. Senn points out that in gunshot wounds the intestines are more likely to escape if the track of the bullet be antero-posterior than if it traverse the abdomen obliquely or from side to side.

Any of the abdominal viscera may suffer from a penetrating wound, whilst fatal hæmorrhage may result from division of one of the large blood-vessels. Wound of the intestine is a most serious complication, and is very likely to be followed by **extravasation of the intestinal contents** into the peritoneum. This extravasation is unquestionably one of the greatest dangers that can

occur in wounds of the abdomen, and gives rise to the most intense peritonitis. It is not, however, an invariable sequence of penetrating wounds of the intestine, especially if the wound be made by a sharp instrument; and even in bullet wounds of the gut no fæcal extravasation may take place. This was well illustrated in a case in University College Hospital of a man who was shot through the abdomen. The intestines, which contained much feculent matter, were traversed by the bullet in four places. He lived twenty-four hours, and yet no feculent extravasation took place. In another case to which I was called, that of a young gentleman who had been accidentally shot through the abdomen with the ramrod of a horse-pistol, the descending colon was cut completely across, and the small intestines perforated in two places; and yet no extravasation took place, though he survived the accident two days. Otis, however, points out in the Report of the American War, that these cases are entirely exceptional, and that in the vast majority of gun-shot wounds of the intestine, fæcal extravasation does take place, and gives rise to fatal peritonitis. That certain cases escape this danger may be due to several causes. In the first place, if the wound in the gut be under a certain size, there is a natural tendency to its occlusion by eversion of the mucous membrane. In other cases again, as in the duodenum or colon, the gut may be wounded at a part that is not covered by peritoneum. Besides this, it must be borne in mind that, though in ordinary language we speak of the "cavity" of the abdomen, there is in reality no such thing; there being no empty space within the peritoneal sac, but the whole of the visceral contents of the abdomen being so closely and equably brought into contact by the pressure of the abdominal muscles and of the diaphragm, that it requires some force for the intestinal contents to overcome this uniform support, and to insinuate themselves between the coils of contiguous portions of intestine. The influence exercised by the continuous pressure of the abdominal walls upon the intestinal contents is well shown by the greater facility with which these escape from a portion of wounded intestine that has been protruded than from one that is still lying within the abdomen. In the former case, fæces will escape from a much smaller aperture than in the latter. The close and uniform contact of the coils of intestine with each other also favours the adhesion of the wounded coil to the neighbouring parts, and thus tends either completely to prevent or to limit fæcal extravasation. In some cases also it is probable that the shock of the injury arrests for the time the peristaltic movements of the gut, and in these circumstances adhesions sufficiently firm to prevent fæcal extravasation may form within twenty-four hours. Thus, in a case under my care, the patient, a young man, aged 22, cut his throat, and stabbed himself twice in the abdomen with a dinner-knife. One of the wounds divided more than a third of the circumference of the jejunum. The patient survived thirty-six hours, and at the *post-mortem* examination the wounded coil was found to contain blood and liquid contents, but it was adherent by firm inflammatory exudation to the neighbouring coils of intestine, and no extravasation had taken place. The patient more frequently escapes without extravasation when the great gut is wounded than when the small intestine is perforated.

When the contents of the intestine escape into the peritoneum diffuse peritonitis almost invariably results, the fæces becoming mixed with the abundant inflammatory effusion. In rare cases, however, extravasations, whether of fæces or blood, if in small amount, may show but little tendency to diffuse

themselves, and may become localized in the neighbourhood of the part from which they were originally poured out; owing, in the first instance, to the surrounding pressure, and, at a later period, to the formation of adhesions between the folds of intestine and the neighbouring viscera.

In rare cases, the existence of a wound of the intestine is proved by the escape of the intestinal contents through the wound in the abdominal wall. In a certain number of cases there is emphysema of the abdominal wall, and very rarely hæmorrhage from the rectum. The evidences of free gas in the peritoneum may sometimes be present. All these symptoms of wound of the intestine are, however, absent in the majority of cases; their presence is of the greatest value in determining the existence of a wound of the bowel, but on the other hand the Surgeon is not justified in concluding that no such injury exists because the above-mentioned symptoms are absent.

2. **Penetrating Wounds of the Abdomen with Visceral Protrusion** are much less common than those above described. Intestine, mesentery, or omentum may protrude through the opening in the abdominal wall, and the bowel may or may not be wounded. The protruded mass is often large in comparison with the aperture from which it escapes, the sides of which constrict it tightly, so as to form a distinct neck to the protrusion. If left unreduced, the mass speedily loses its polish and bright colour, becoming dull and livid from congestion; it then swells, and soon becomes gangrenous from the pressure exercised upon it by the sides of the aperture.

The existence of a wound of the protruded bowel will readily be ascertained by the escape of gas, or of the fluid contents of the gut. The characters of the wound vary, as Travers pointed out, according to its size. If it be a mere puncture, or even an incision two or three lines in length, eversion or prolapse of the mucous membrane will take place, so as to close it sufficiently to prevent the escape of the contents. If the aperture be above four lines in length, this plugging of it by everted mucous membrane cannot occur, and then the contents of the bowel escape; but, even in these circumstances, there will be a tendency to the protrusion of the membrane, which forms a kind of lip over the edge of the cut.

Although the protruded portion of intestine be uninjured, it must be remembered that a wound of some neighbouring coil, which has not escaped from the abdomen, may yet be present.

Prognosis of Penetrating Wounds of the Abdomen.—Penetrating wounds of the abdomen are amongst the most fatal of all injuries. In the reports of the American Civil War, thirteen cases of punctured or incised wounds without injury to viscera are recorded, with nine recoveries, and nineteen similar injuries from gunshot, with twelve recoveries. Of fourteen recorded cases of punctured or incised wounds with visceral lesion only two recovered. The recorded cases of gunshot wound with visceral injuries amounted to 3,771, and of these only 421 recovered, and in 242 the result was unknown. In the great majority of these cases the exact visceral injury was not recorded. In seventy-nine the stomach was wounded, and of these nineteen recovered. In 653 the intestines were wounded, and of these 118 recovered; but the exact part of the gut is not specified in a large proportion of these cases. Otis, however, states that he has been unable to find a single incontestable case of bullet wound of the small intestine in which recovery took place. On the other hand, there are good records of at least fifty-nine cases

of wound of the great intestine, which terminated favourably, usually with a temporary establishment of a fæcal fistula. The liver was wounded in 173 cases, of which sixty-two recovered. Injuries of the spleen were more fatal, only two recovering out of twenty-nine cases. In seventy-eight cases the kidney was wounded, and of these twenty-six recovered. Of the 2,599 cases in which the lesion was not specified, only 186 are reported as having recovered. It is evident, therefore, that the records of the cases in which the exact injury is specified give much too high a proportion of recoveries, the mere fact of the patient's surviving having led to a more detailed account of the injury being preserved.

Treatment.—In many cases there is doubt as to whether or not the wound has actually penetrated the peritoneal cavity. Under these circumstances it is the duty of the Surgeon carefully to enlarge the wound and follow the track to its deepest part, with the object of ascertaining the presence or absence of penetration. By this means much more certain information is obtained than by the mere use of a probe, and with less risk of converting a non-penetrating wound into a penetrating one. Having in this way determined that the wound does really enter the abdominal cavity, the Surgeon should proceed to determine whether or not visceral lesion exists. If wounded bowel is protruding from the wound, the nature of the injury is obvious, but if no such protrusion exists, the presence of a wound of the stomach or intestine cannot as a rule be recognized with certainty by the symptoms. It has already been pointed out that the nature of the injury is but rarely evidenced by the escape of intestinal contents from the wound or the existence of the other symptoms mentioned above (p. 878). In the unusual cases in which the wound in the abdominal wall is sufficiently extensive to allow a thorough examination of the contents of the abdomen, this should be done. In simple stabs and in gunshot wounds this is impossible, and the only way of clearing up the uncertainty is to enlarge the wound, or to open the abdomen in the middle line, and to examine the abdominal viscera. This treatment may seem severe, but experience has taught us that an exploratory incision into the abdomen, if undertaken with proper precautions, is practically free from danger; and, on the other hand, if we wait till the injury to the intestine becomes evident by the commencement of septic peritonitis, the case is altogether hopeless. The advantages of the median incision over enlargement of the wound are very great. It enables the whole length of the intestines to be systematically examined, commencing from the cæcum, which is usually easily recognizable, and working upwards to the duodenum. It also greatly facilitates the necessary cleaning of the abdominal cavity. In performing the operation all the details described in Chap. LXI., Vol. II., must be strictly attended to. The method of treating the intestine is described on pp. 884 *et seq.*

Gross many years ago expressed the opinion that in such cases "the duty of the Surgeon is to enlarge the abdominal orifice, to seek for the wounded tube, and to sew up the cut." He did not, however, anticipate much benefit from this treatment in gunshot wounds, owing to the multiplicity of the openings in the gut met with in such cases.

Reference must here be made to a method introduced by Senn, of Chicago, for the detection of wounds of the stomach and intestines. He has shown that hydrogen gas injected into the rectum can be made to pass along the whole length of the intestinal tract as far as the stomach, from which it can

be withdrawn by an œsophageal tube. If, however, the intestine be wounded, the gas fails to reach the stomach, but passes into the peritoneal cavity, and escapes from the external wound if such be present. In one hundred cases of experimental gunshot wounds of the abdomen of dogs, the method did not fail. In six cases of gunshot wound, Senn employed the method clinically: in two cases which recovered with expectant treatment, the absence of intestinal wound was proved by the hydrogen test. In one case in which eleven wounds of the intestine were successfully sutured, one of them would have escaped notice had not hydrogen been injected after the other wounds had been closed. The method has not proved so certain in the hands of some other Surgeons who have employed it, but it certainly seems worthy of further trial.

Morton of Philadelphia has collected 79 cases in which laparotomy was performed for stab wounds of the abdomen; of these 48 recovered and 31 died. This series includes 13 wounds of the stomach, with 8 recoveries; 27 wounds of intestine, with 14 recoveries; 7 wounds of the mesentery or omentum with 5 recoveries. In one case the spleen was excised with a fatal result. Of 6 cases of wounded liver 2 recovered, the wound being sutured in one and packed with gauze in the other. In one case an intraperitoneal wound of the bladder was successfully sutured. In 4 other cases ending fatally there was peritonitis at the time of the operation in 3, and injury to the colon in one. Of 19 cases in which no visceral injury was found 16 recovered. In one case ending in recovery the nature of the injury is not stated.

Of 110 cases of gunshot wounds of the abdomen treated by laparotomy 36 recovered and 74 died. In these the intestine only was wounded in 63, and 21 recovered; in 5 the stomach, and 1 recovered; in 6 the stomach and intestines with one recovery. Wounds of the liver were present in 15 instances, with six recoveries, in one of which the right kidney was excised. Four times the abdomen was laid open and no visceral wounds were discovered; all of these recovered. In most of the remaining cases the injuries were complicated, and in 4 there was peritonitis at the time of operation.

Miles of New Orleans has recorded a case of gunshot wound of the abdomen in which sixteen perforations of the small intestine and three wounds of the mesentery were sutured, the patient making a speedy recovery.

The results of operative interference in penetrating wounds of the abdomen must on the whole be looked upon as hopeful. The mortality after gunshot wounds so treated is as high as 67 per cent.; but in the large majority of the cases the injuries would have been almost necessarily fatal. It is important also to observe that of 23 cases in which no internal injuries were found only 3 died.

Although therefore it may be laid down as a general rule that penetrating wounds of the abdomen should be treated by an exploratory laparotomy, circumstances may arise in which this treatment is impracticable. Without all the means necessary for efficient antiseptic precautions it should not be undertaken in doubtful cases. The wound should be closed with sutures, preferably of silver wire, and a dry absorbent dressing applied. The patient should have a full dose of opium; about two grains of the solid opium or a hypodermic injection of the third of a grain of morphia may be given, after which the effect must be kept up by doses of half that amount, repeated every four or six hours. This serves the important purpose of arresting the peristaltic

movement of the intestine and thus preventing extravasation from any wound of the bowel which may be present.

Travers showed experimentally—and his investigations have been confirmed by subsequent observations on the human subject—that wounds of the intestines are closed by lymph that is thrown out, not only from the contiguous peritoneal surfaces of the part actually injured, but from that of neighbouring coils; so that the aperture in the gut becomes permanently glued and attached to the structures in its vicinity. In order that this process should take place, it is necessary that the movements of the bowels should be arrested until the adhesions have become firm enough to prevent extravasation of fæces. The patient must be kept perfectly quiet in bed, and no nourishment given but iced milk, or milk and soda-water, and some cold beef-tea or essence of meat, during the first three days. The bowels should not be opened by aperient medicine, lest abdominal irritation be set up, but oleaginous enemata may be administered at the end of a week or ten days.

If the symptoms of extravasation of feculent matter into the abdomen present themselves, an attempt must be made to facilitate its escape externally. The dressing must be removed, and, should the lips of the wound have already become adherent to one another, they should be carefully separated. Should an immediate escape of feculent matter take place, a drainage-tube should be inserted to ensure a ready exit for the discharges.

In those cases in which the wound is situated in the loin the gut may be wounded without implication of the peritoneum, as in lumbar colotomy. In these recovery commonly takes place with the formation of a fæcal fistula. In the early stages it may be necessary to enlarge the opening to prevent burrowing of matter in the loose tissue around the gut.

When **a portion of intestine or of omentum has protruded,** it should be carefully cleaned with an antiseptic lotion and replaced as speedily as possible, before strangulation has occurred, which may occasion gangrene.

If the protruding bowel be wounded it must be treated in the manner presently to be described.

Experience has shown that carbolic acid lotion (1 in 40), or perchloride of mercury (1 in 2000), or dilute tincture of iodine (ʒij to Oj) exerts no injurious influence on the bowel. In replacing the protruded gut, the abdominal muscles should be relaxed by bending the thighs upon the abdomen and raising the shoulders, when the Surgeon may gradually push back the protrusion by steady pressure upon it; he must not, however, employ any force, nor any rough handling of the exposed parts; but if their return cannot readily be effected, owing to the constriction of the neck of the protrusion, the aperture through which they have escaped must be enlarged in a direction upwards, by means of a probe-pointed bistoury, or a hernia-knife guided by a flat director. In replacing the protruded parts, whether by the aid of incision or not, care must be taken that they are fairly put back into the cavity of the abdomen, and not pushed up into the sheath of the rectus, or into the subserous areolar tissue lying before the peritoneum; an accident that would be fatal by allowing the constriction of the neck of the protrusion to continue unrelieved. The protruded gut or omentum should be allowed to remain in the immediate neighbourhood of the wound, to which it will contract adhesions; and through which its contents may escape, in the event of any sloughing taking place. After the gut has been returned, the external wound must be closed by sutures.

If the protrusion be inflamed, it must equally be replaced without delay; but should the intestine have become gangrenous from continued constriction and exposure, the Surgeon will have the choice between two lines of treatment:—excision of the gangrenous portion of intestine, or the formation of an artificial anus to be cured subsequently by a secondary operation.

If any difficulty be found in returning a mass of protruded omentum it may be ligatured in one or more pieces with carbolized catgut or silk, and cut off, after which the stump can easily be passed into the abdominal cavity. If the protruded omentum be gangrenous, it must be excised on a level with the peritoneum, to the aperture in which that portion lying within the abdomen will have contracted adhesions.

Treatment of Wounded Bowel.—In most cases of wound of the stomach or intestine by stabs of the abdomen it will be found possible to close the wound with sutures. In some cases of gunshot wound, however, and sometimes when the intestine is ruptured by a contusion of the abdomen, the nature of the injury renders this simple treatment impossible. Under these circumstances excision of the damaged segment of bowel and suture of the two ends have been successfully practised.

For the successful suture of a wound of the bowel it is essential that the

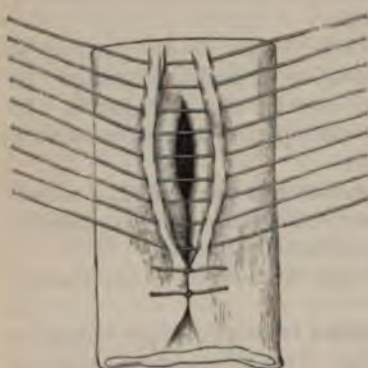

Fig. 322.—Application of Lembert's Suture to Wounded Bowel.

Fig. 323.—Lembert's Suture. *a*, serous; *b*, muscular; and *c*, mucous coat.

serous surfaces be brought well into contact. It is almost needless to observe that no union can possibly take place between two mucous surfaces, or between a serous and a mucous surface. Leakage after suture is most apt to occur from the extremities of the wound, and whatever form of suture is employed, it must be commenced and finished well beyond the ends of the opening.

Carbolized or chromic catgut and very fine carbolized silk are the materials usually employed, and it is very possible that these may be absorbed without ulcerating into the gut if they are applied so as not to include the mucous membrane. Very fine silk is generally preferred as being more manageable, and tying more accurately. The sutures should be introduced by means of fine round sewing needles. The ordinary flat surgical needle cuts the gut to such an extent that the sutures may fail to hold.

With the view of stitching together the serous surfaces, much ingenuity has been displayed, and many devices have been practised. The mode of

application most frequently adopted in the present day is that recommended by Lembert. The needle is introduced about a quarter of an inch or a little more from the wound, and made to penetrate as far as the submucous tissue; it is then brought out again about one-sixth of an inch from the edge of the cut on the same side; on the opposite side, it is made to enter one-sixth of an inch from the edge of the cut and brought out at a quarter of an inch from it (Figs. 322, 323). The stitches must not be more than a line apart, and the whole number required must be introduced before any are tightened. One or more stitches at each end must be inserted beyond the limits of the wound, otherwise leakage is inevitable. When the sutures are tightened the mucous membrane is inverted, and the serous surfaces are brought into accurate contact. This suture is easily applied in the stomach or large intestine, but from the thinness of the coats of the small intestine it is not quite so easy of application in that part. If there is any difficulty the suture may be applied in the same way, but may be made to penetrate the whole thickness of the gut on each side, as recommended by Jobert (Fig. 324).

Fig. 324.—Jobert's Suture for partial division of the gut.

Fig. 325.—Application of Gely's Suture to Wounded Bowel.

The great objection to this is, that the stitches are apt to become irritating by absorbing the contents of the intestine. When the lips of the wound have been brought into apposition, the ends of the sutures should be cut short close to the knots.

Gély's method of suture is sufficiently explained by the accompanying figure (Fig. 325). It undoubtedly brings the serous surfaces into good apposition, but is not so easy of application as Lembert's method. All continuous sutures have the great disadvantage that if one stitch happen to cut the whole becomes loose.

Various methods of suture have been devised for the union of intestine which has been completely divided, or for use in those cases in which resection of a portion of damaged bowel is necessary. The same methods are available after the removal of portions of intestine for gangrene in strangulated hernia, for adhesion to abdominal tumours, for malignant growths of the gut, &c.

The damaged loop of intestine must be carefully withdrawn from the abdomen, and the incision in the abdominal wall closed with carbolized sponges. The bowel is next clamped above and below the part to be excised.

This can be quite efficiently done by the fingers of an assistant, but numerous clamps have been devised, of which one of the best is that recommended by Makins. A simple method consists in surrounding the gut with a piece of small drainage-tube passed through the mesentery and knotted or held in catch-forceps. The segment of bowel is now removed, care being taken that the incisions are made well beyond the diseased or injured portion. If the part requiring removal is small no mesentery need be excised; if large, a triangular piece of the mesentery should be cut away, and the edges sutured. Whatever method be employed for uniting the intestine, great care must be taken in inserting the sutures at the mesenteric border, where a narrow strip of the muscular coat is exposed between the layers of the serous membrane.

The principal methods of uniting the intestine will now be shortly described.

1. *Czerny-Lembert Method.*—This consists of a double row of interrupted

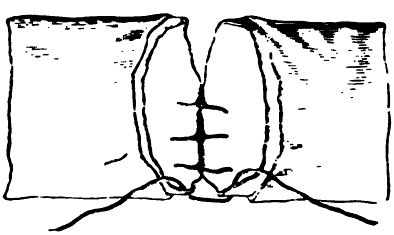

Fig. 326.—Czerny-Lembert Suture for Divided Intestine. First Stage: Application of Sutures to the Mucous Membrane.

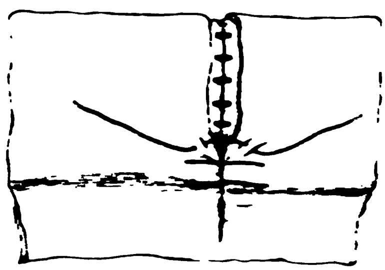

Fig. 327.—Czerny-Lembert Suture for Divided Intestine. Second Stage: Application of Sutures to the Serous and Muscular Coats.

sutures. The first row approximates the edges of the mucous membrane, and the knots are as far as possible tied inside the bowel. The second row includes the serous and muscular coats, and is passed after the manner of Lembert's

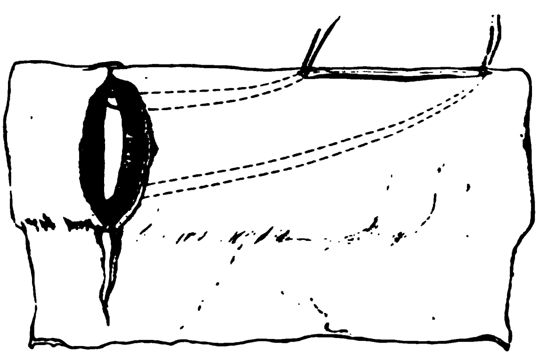

Fig. 328.—Maunsell's Method of Intestinal Suture. First Stage.

suture above described (Figs. 326, 327). MacCormac looks upon the inner row of sutures as unnecessary, and advises the use of a single row of Lembert's sutures only.

2. *Maunsell's Method.*—The ends of the bowel are first brought together by two temporary sutures, one introduced at the mesenteric border and the other opposite this. A longitudinal incision about an inch and a half long is made in the lower segment of the gut opposite the mesenteric border; the incision begins one inch from the line of division (Fig. 328). The ends of the temporary sutures are drawn out through this incision, and by gentle traction

Fig. 329.—Maunsell's Method. Second Stage: Introduction of Sutures.

the divided ends of the gut are invaginated through it, the peritoneal surfaces being in contact all round. Sutures are now easily passed through all the coats of the two portions of intestine (Fig. 329). The temporary stitches are now removed, the gut drawn back, and the incision in the lower part closed with

Fig. 330.—Maunsell's Method. Third Stage: Closing Incision with Lembert's Sutures.

interrupted Lembert's sutures (Fig. 330). Maunsell recommends stout horse-hair as the best material for the sutures.

3. *Paul's Method.*—A decalcified bone tube, having a needle and strong silk thread attached, is sewn with fine catgut into the upper end of the intestine. The traction thread is passed through the wall of the lower segment about three inches down (Fig. 331). The cut ends of the intestine are now sewn together with fine catgut, and the edges of the divided mesentery adjusted. By firm traction on the thread a short invagination is produced, and retained in position by three or four Lembert sutures (Fig. 332). The traction thread is then cut off short, and its ends dropped into the bowel. The principle of union of divided intestine by the formation of an invagination

was first recommended by Jobert in 1822. His method is illustrated in the accompanying diagrams (Fig. 333, 334). Senn has recommended a very similar method; instead of the bone tube an india-rubber ring is stitched with catgut into the proximal end of the bowel, before the invagination is made.

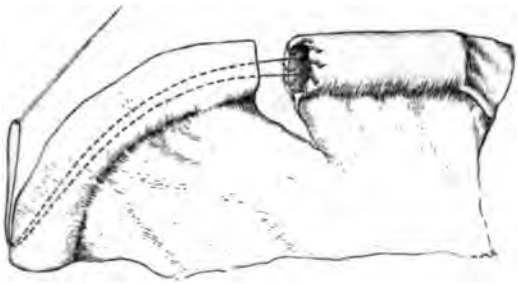

Fig. 331.—Paul's Method of Intestinal Suture. The bone tube is secured in position by a fine suture, and the silk threads attached to it are passed along the distal end of the bowel.

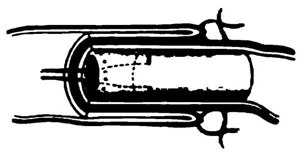

Fig. 332.—Paul's Method. Diagram showing production of invagination.

All the above methods of intestinal suture have been successfully employed, but at the present time it is impossible to decide which is likely to be found the most generally useful. The first two methods have the advantage of requiring no special apparatus. The Czerny-Lembert suture or some modification of it is easy to apply and has given excellent results. Objection has been raised to Maunsell's method that the sutures pass through all the coats of the bowel. The risk of leakage along the sutures is small if horsehair be used as recommended by Maunsell, whilst

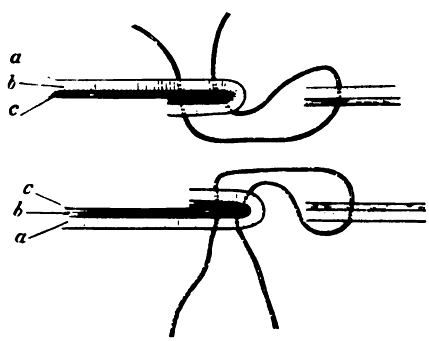

Fig. 333.—Jobert's Suture for complete Transverse Division of the Intestine.

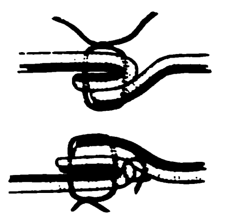

Fig. 334.—The Suture Tightened. The figure shows a Lembert's Suture introduced to give additional security.

it may be advisable to insert a few additional points of Lembert suture as suggested by Stanley Boyd, who has successfully employed the method. Senn's method of so-called "lateral anastomosis" by the use of decalcified bone plates does not appear to present any special advantages in the suture of two segments of intestine of the same calibre (see Chap. LXIV.). In any case of intestinal suture additional security may be attained by adjusting an omental graft over the line of the sutures, as suggested by Senn.

The sutured intestine is carefully cleansed and replaced in the abdomen,

and great care must be taken in thoroughly purifying the peritoneal cavity. This is best done by repeated sponging, aided perhaps by flushing with water sterilized by boiling or with boric acid lotion.

Finally, the wound in the abdominal wall is closed with silk sutures passed through its whole thickness.

In the after-treatment, care must be taken, by attention to the position of the patient, and by the free administration of opium, to keep the bowel as quiet as possible ; the urine should be drawn off twice in the twenty-four hours, and no purgative whatever administered, lest, by the excitation of peristaltic action, adhesion be disturbed, and extravasation take place. After the lapse of eight or ten days an enema may be thrown up, and repeated from time to time. No food should be allowed for the first three days, during which time ice and barley-water should be freely taken : after this, beef-tea, and light food that leaves no solid residue, may be given. It is of great importance that no solid food should be administered for at least two or three weeks after the occurrence of the injury. In a case of knife-wound of the intestine which was under my care, the patient, who was progressing very favourably, and eventually recovered, nearly lost her life by eating the pulp of an orange on the tenth day.

In the treatment of extensively wounded intestine, the only alternative open to the Surgeon is to fix the edges of the opening in the gut to the margins of the external wound in the skin, in the hope of an artificial anus being formed, which may possibly afterwards be closed, either by the contraction of the wound or by operation at a later period. This method should, however, never be adopted when resection and suture are possible, as should the patient escape the danger of peritonitis, the operation for the subsequent cure of the artificial anus is necessarily a serious one.

WOUNDS OF THE KIDNEY.—These may be caused by stabs or bullet-wounds in the lumbar region. The symptoms characteristic of this injury are the same as in rupture (p. 873), with the addition of the open wound, from which urine may escape. The experience of operations for the removal of stones from the kidney has taught us that a simple wound of that organ is not accompanied by any very serious danger if proper drainage be provided. In deep stabs in the loin, implicating the kidney, the best practice would be to enlarge the wound so as to expose the gland. If it be so injured that it is not likely to heal, or if there be hæmorrhage which threatens life, the kidney may be removed (see Nephrectomy). If it is but slightly wounded, a drainage-tube may be inserted, and the wound treated as after nephrotomy (see Nephrotomy). Gunshot wounds of the kidney are usually complicated by injuries of other viscera and wounds of the peritoneum, and in these but little can be done. Enlarging the wound if it be in the loin, and providing good drainage, would give the patient the best chance of life.

CYSTS IN THE ABDOMEN AFTER INJURY.—Large collections of fluid are occasionally met with in the abdomen as a remote consequence of injury, not connected with the kidney. These seem to be, in some cases at least, formed by imperfectly absorbed extravasations of blood enclosed in a space formed by adhesions amongst the surrounding viscera. In one case under Marshall in University College Hospital the injury had been in the region of the spleen, and some months after more than a pint of darkly-stained fluid was removed from a cyst filling the left side of the abdomen. The cavity was drained, and the patient, a girl aged about 12, recovered.

Cysts in connection with the pancreas which occasionally follow abdominal injury are described in Chap. LXIV., Vol. II.

TRAUMATIC PERITONITIS is the great danger to be apprehended in all serious injuries of the abdomen. It occurs in two forms, the localized and diffuse. **Localized Peritonitis** may follow a severe contusion, without recognizable injury to any viscus. It occurs also in cases of wound or rupture of the intestine, in which there is no extravasation of the contents of the gut, and in slight lacerations of the liver, spleen, or kidneys. Localized peritonitis is accompanied by the pathological phenomena common to all inflammation; the vessels become engorged and exudation takes place, composed of blood-plasma, more or less pure, and migrating white corpuscles. The exudation coagulates, the fibrin and the corpuscles forming the "lymph" which glues the contiguous surfaces of the peritoneum to each other, and the serum draining away into the cavity of the abdomen, from which it is rapidly absorbed. In these cases, in which there is no persistent source of irritation, the inflammation speedily subsides, the exudation becomes penetrated by new vessels, and finally firm bands of fibrous tissue are formed, uniting the coils of intestine or the injured viscera to each other or to the abdominal wall. In other cases again, firm adhesions may form at the circumference of the inflamed area, and the process may reach the stage of suppuration opposite the wound of the gut in consequence of a very slight escape of its contents, or the same may occur opposite a wound or laceration of one of the solid viscera. There is thus formed a collection of pus bounded by the neighbouring viscera or coils of intestine, and shut off by firm adhesions from the general cavity of the abdomen. Such a collection of pus may finally burst through the surrounding adhesions, and thus set up diffuse peritonitis, or it may make its way into one of the hollow viscera or to the skin, and be safely discharged.

The **Symptoms of Localized Peritonitis** are intense pain and tenderness over the affected spot; often aggravated by movement or respiration. There is some elevation of temperature, and there may be vomiting. Should a localized collection of pus form, the tenderness and pain will remain, there will be a definite swelling and hardness to be felt at the affected part. The febrile disturbance remains unrelieved, and there may be one or more rigors. Should the pus burst through the surrounding adhesions and find its way into the general cavity of the peritoneum there will be intense sudden aggravation of the pain, followed by the symptoms of diffuse peritonitis.

Diffuse Peritonitis occurs first, as the result of extravasation of the contents of the gut, either in penetrating wounds from without or from within the gut, or from ruptures from external violence; and secondly, from decomposition of extravasated blood or inflammatory exudation in the cavity of the peritoneum. The putrefactive ferment may find its way into the cavity of the peritoneum from without by means of an external wound, or from within, from the intestine, either by rupture or perforation of its coats, or in consequence of sloughing of the wall of the gut from the violence to which it has been exposed. The experience of the operation of ovariotomy shows us that the peritoneal cavity may be opened and freely exposed to the air without any great risk of the occurrence of septic peritonitis provided that it be thoroughly cleaned and no decomposable matter be left within it. The subject has further been experimentally investigated in animals by Wegner, and the results obtained by him tend to show, that if only a portion of the peri-

toneum be exposed to irritation, the liquid exudation is rapidly absorbed by the healthy part of the membrane, so that the cavity is kept dry and free from putrescible matter. In rabbits it was found that a considerable quantity of simple water, or even of fluids containing septic bacteria, could be injected into the peritoneal cavity without evil results following, the fluids being rapidly absorbed and carried into the blood-stream. If, however, the quantity injected was greater than could be thus rapidly disposed of, septic peritonitis invariably followed. It seems probable, therefore, that the occurrence of septic peritonitis after wounds opening the cavity of the abdomen, whether in surgical operations or in accidents, depends to a great extent upon the amount of putrescible matter in the cavity. If from a wound of some considerable vessel a large quantity of blood is extravasated, or if in consequence of local irritation, as from a wound or rupture of the gut with or without slight fæcal extravasation, the amount of inflammatory effusion is greater than the uninjured part of the peritoneum can rapidly absorb, the putrefactive ferment finds material upon which it can act, and decomposition and septic peritonitis follow. With a clean peritoneal cavity and little exudation the patient escapes. In injuries of the liver, peritonitis may result from the escape of bile into the cavity of the abdomen without decomposition taking place.

In a case of diffuse peritonitis the *post-mortem* examination shows excess of fluid which, in the earlier stages, is found chiefly in the most dependent parts, the cavity of the pelvis and the flanks. The intestines are reddened, and the coils are distended. In the earliest stage the peritoneal surface has lost its natural gloss to some extent, and feels greasy. When the inflammation is further advanced, lymph is found on the gut, and especially in the angles between two contiguous coils. If two coils be separated, they will be found paler in colour from mutual pressure at the points which have been in contact, and marked by a darker red line where they separate. The intestines are very slightly adherent to each other. In the most dependent parts of the cavity is a large quantity of turbid serum, mixed with shreds of coagulated exudation, or the fluid may assume the form of thin pus. It is usually very offensive, and is excessively dangerous if inoculated, giving rise to the worst forms of dissecting-wound. Gas from the intestines is also frequently met with in the abdominal cavity.

The **Symptoms of Diffuse Peritonitis** are pain and tenderness, at first most marked in the neighbourhood of the injury, but gradually extending to the whole abdomen, and aggravated by occasional stabbing pains. This is followed by tympanitic distension of the abdomen, from paralysis of the muscular coat of the gut, and also in some cases partly from the escape of flatus into the peritoneal cavity. The patient suffers great distress; he lies on his back with his knees drawn up to relax the abdominal muscles, and the slightest pressure causes intense agony. Occasionally, respiration is seriously interfered with by the distension of the abdomen. Vomiting is an early symptom; the contents of the stomach are brought up without straining, seeming to pump out almost without effort. As the effusion increases, there will be dulness in the flanks, shifting its position as the patient is moved, and tympanitic resonance in front. As the case advances, the vomited matter becomes dark from admixture of blood from the congested mucous membrane. Hiccup may be a troublesome symptom. The pulse is at first small, quick,

and hard, often assuming a wiry, incompressible character. The temperature is at first high, reaching often 103° or 104° Fahr.; but in septic cases it usually falls rapidly before death, and may even become subnormal. There is great anxiety of countenance, and before death the extremities become cold, and the patient dies with the signs of collapse. This diffuse traumatic peritonitis will set in and run its course with great rapidity. In a case in University College Hospital already alluded to, of bullet-wound in the abdomen, the patient lived twenty-four hours. Two or three pints of serous effusion with much puriform fluid were found; and great reddening of the whole of the visceral, and much of the parietal, peritoneum had ensued. In another case of rupture of the ileum, the consecutive peritonitis proved fatal in about thirty hours after the accident. This extreme rapidity in its course and fatal termination is due to the rapid absorption of the unhealthy inflammatory products, in septic cases aggravated by the presence of the products of putrefaction; in fact many of these cases form the most marked instances of this form of blood-poisoning. The rapidity of the fatal termination is due to the great extent of the absorbing surface, and the large dose of the poison that is thus taken up in a very short time.

Treatment of Traumatic Peritonitis.—In the treatment of this complication, we must be guided by the character of the inflammation. If the peritonitis be localized, leeches may be applied over the tender part of the abdomen, followed by hot fomentations, and opium must be administered in moderate doses. Operative interference should be avoided, unless there be evidence that suppuration has occurred, in which case the abscess should be opened and drained. Great care must be taken not to break down the adhesions by which the abscess is surrounded, lest general peritonitis be the result.

The occurrence of diffuse peritonitis after an abdominal injury is usually an indication for immediate laparotomy, and the same treatment should be followed, even though the peritonitis has occurred after an operation for wound of the intestine or stomach. The chances of recovery under these circumstances are remote, but success has followed the closure of a wound of the bowel even when peritonitis was already present. The peritoneal cavity should be carefully flushed, and free drainage provided for by a tube passed down into the pelvis.

Aperients should be strictly avoided, and opium given in doses sufficient to allay pain. In these cases nourishment must be given in a fluid form only, and the administration of stimulants will often be required.

INJURIES OF THE PELVIC VISCERA.

Bladder.—**Rupture of the Bladder,** from blows upon the abdomen, is not a very unfrequent occurrence. It can scarcely happen when the organ is empty, as it then lies under cover of the pubes. But when the bladder is distended, and thinned proportionately to its distension, it may very readily be ruptured, even by slight degrees of external violence, as by one man rolling over another in a drunken scuffle, or by a person running against a post, or falling out of bed.

When the bladder is ruptured by a blow on the abdominal wall, the rent takes place almost invariably through that portion of it which is covered by peritoneum, which is the least supported as well as the thinnest part of the

viscus. Hence there is extravasation of urine and blood into the abdominal cavity. When **the bladder is wounded** by gunshot or other injury, such as by falling on a spike, which penetrates the perinæum or rectum, or by a splinter of a fractured pelvis, those anterior and inferior parts of the organ which lie outside the peritoneum may be perforated, and thus intraperitoneal extravasation may not occur. In any case the shock following rupture of the bladder is usually great; but the secondary consequences will of course depend on the situation of the rupture or wound. If the laceration have occurred in those portions of the viscus that are invested by peritoneum, the urine will at once escape into the pelvic and abdominal cavities, and speedily occasion death by causing intense inflammation. If, on the other hand, that portion of the organ has been ruptured which is uncovered by the peritoneum, the urine may infiltrate the areolar tissue between this membrane and the abdominal wall, and, diffusing widely, produce destructive sloughing of the tissues. In these cases life may be prolonged for some days, when the patient commonly sinks from absorption of septic matter from the gangrenous tissues.

The danger of a wound of the bladder is due to the effusion of continually increasing quantities of urine. It is in exact proportion to the difficulty that the extravasated urine has in finding an exit. Hence an open wound of the bladder is by no means so dangerous as a subcutaneous rupture. Many patients have recovered whose bladders have been perforated and traversed by bullets, for the urine finds a free exit through the apertures, and consequently does not tend to extravasate. Guthrie relates several cases of this kind; and Thomson saw fourteen cases after the battle of Waterloo, in a fair way of recovery. In the American War, out of one hundred and eighty-three reported cases of gunshot wound of the bladder, eighty-seven patients survived, "though a large majority suffered from grave disabilities, and many from distressing infirmities, which resulted fatally in a few cases after years of suffering." Thus, although we may look upon this accident as of the gravest character, yet it is by no means necessarily fatal. Probably in most of those who recovered, the wound did not implicate the peritoneum.

Symptoms.—The situation of the injury in the hypogastric region, the supervention of collapse followed by intense burning pain in the abdomen and pelvis, with inability to pass urine, or, if any have escaped from the urethra its being tinged with blood, are usually sufficient to point to the nature of the accident. If, in addition, it be found on introducing a catheter that the bladder is contracted and empty, or that but a small quantity of bloody urine escapes, not in a uniform stream, but rising and falling with the movements of the abdominal muscles, the Surgeon may be sure that this organ has been ruptured. In the case of gunshot injury, the escape of urine which generally takes place through the track of the bullet will afford incontestable evidence of the mischief that has been produced.

When the bladder is ruptured through that portion which is covered by peritoneum, the urine escapes into the abdominal or pelvic cavity: there, however, it does not at first diffuse very widely—remaining, under the influence of gravity, chiefly in the pelvic cavity, with the small intestines floating above it. This localized extravasation may be emptied by the catheter through the rent in the bladder, hence the escape of urine is not incompatible with rupture of the bladder. This important practical point is well illustrated by the following case. A man was admitted into the Hospital under my care,

who had suffered rupture of the upper and posterior wall of the bladder by falling down stairs; when admitted he was profoundly collapsed and semi-unconscious. The abdomen was swollen, tender, tympanitic in front, dull in the flanks. On passing a catheter the bladder was found to be empty and contracted: but with a little gentle manipulation the point of the instrument could be passed through the laceration in the posterior wall of the bladder, and a large quantity of clear urine was drawn off. For two days the patient seemed to be doing well. The catheter was taken out to be cleaned, could not be introduced afterwards, little urine escaped, and the patient died of peritonitis. In another case under my care, the patient lived ten days, the bladder being kept drained.

Keen suggests injection of filtered air or hydrogen: if no rupture exists a tense tympanitic tumour will rise above the pubes; whilst if the bladder is ruptured the air will escape into the peritoneal cavity. As an additional means of diagnosis in a case where rupture of the bladder is suspected, it has been recommended to inject it with boric acid lotion; if the bladder be intact it will be felt to become gradually distended and the total quantity of fluid injected will return through the catheter.

When the rupture does not implicate the peritoneum the most important point in the **Treatment** consists in drainage of the organ, in order to prevent extravasation of urine. This is best effected by means of a full-sized catheter, tied in and connected to a long india-rubber tube passing into a basin of carbolic acid lotion. Should this not be efficient, free drainage must be ensured by suprapubic or perineal cystotomy.

When the peritoneum is implicated, drainage by a catheter or cystotomy is much less hopeful, and although cases have recovered when treated in this way, the results have not been sufficiently satisfactory to justify us in relying upon them. Abdominal section and suture of the rent in the bladder hold out a far better prospect of success.

Kerr of Washington has collected 29 cases in which this operation has been performed up to the middle of 1893. In 23 of these the wound in the bladder was closed by sutures; of these 9 recovered. Of the four successful cases in this country, two were treated by MacCormac, one by Holmes and one by Walsham. In two earlier cases under Heath and Willett the sutures gave way and death occurred from peritonitis. In 6 cases no sutures were introduced. Of these 3 recovered, but in one it was not certain that the peritoneum was wounded; in one of these cases a large drainage tube was inserted into the peritoneum, and in one a stellate rent in the bladder was packed with iodoform gauze and a drain placed on either side of it. Of the 3 fatal cases two were treated by drainage and in one the rupture was not detected at the operation. The *post-mortem* examination showed a puncture not implicating the serous coat, made by a fragment of a fractured pelvis. Thus of the 29 cases in which laparotomy was performed 12 recovered—a much higher rate of success than has been obtained by any other means. The best operation is undoubtedly complete suture. The stitches should include the serous and muscular coats only, and must extend beyond the wound at each end to prevent leakage. The perfection of the suturing may be tested by moderately distending the bladder with boric acid solution. If the cavity of the pelvis can be thoroughly cleaned, and the rent is perfectly closed, no drainage of the abdominal cavity is necessary. If, however, there is much peri-

tonitis, a drainage tube should be inserted. The bladder must not be allowed to become distended after the operation, but it is not advisable to tie in a catheter on account of the risk of cystitis.

Foreign Bodies, such as pieces of catheters, tobacco-pipes, pencils, &c., are occasionally met with in the male urinary organs, having been introduced through the urethra. In some cases they are soon spontaneously expelled. If left in the bladder they become encrusted with phosphates and thus often become the nuclei of large and irregularly-shaped calculi; hence it is absolutely necessary to remove them speedily. This may occasionally be done by fortunately seizing the foreign body with a small lithotrite or urethral forceps at one end, and withdrawing it in the direction of its long axis. But if this procedure be unsuccessful, it must be cut out. This is most safely done by suprapubic cystotomy.

Bullets, pieces of clothing, &c., are occasionally lodged in the bladder, in gunshot wounds of that organ. These speedily become encrusted with phosphatic deposits, and, giving rise to the symptoms of stone in the bladder, require to be removed by cystotomy, an operation that has proved very successful in these cases, evidently in consequence of the healthy condition of the urinary organs. Dixon has collected from various works the details of 15 cases, in which balls, that had either primarily entered the bladder, or had found their way into this organ by abscess or ulceration after having been lodged in the neighbourhood, were extracted by operation. In 10 of these the result was successful; in the remaining 5 no record is made of the termination. In the Surgical History of the American War, 21 cases are recorded in which lithotomy was performed for the extraction of foreign bodies, or traumatic calculi. Of these three died, the result in one case is unknown, and the rest recovered. In 13 cases the missile itself was removed from the bladder; in 3, a splinter of bone formed the nucleus; in one the stone had formed round a piece of cloth, and in another on a curl of hair from the pubes; in the remaining cases soft organic matter of doubtful nature formed the nucleus.

Arrow-heads have also been met with in the bladder. There is, in the Army Medical Museum at Washington, a remarkable specimen of an Indian arrow-head which formed the nucleus of a large phosphatic calculus.

In the female also, various foreign bodies are occasionally passed up the urethra, and slipping from the fingers, are lost in the bladder. Hair-pins, bougies, pencils, penholders, and a vast variety of similar objects have here been met with. As a rule they may easily be extracted through the urethra, which should be expanded by a proper dilator.

WOUNDS OF THE ORGANS OF GENERATION in the male may be accidental, occasioned by sharp instruments or gunshot, or may be self-inflicted. When involving only the integuments, they present nothing peculiar and do not differ from similar wounds in other situations, except in the great reparative power that the scrotal and penile coverings possess. Even when the whole of the skin of the part has been torn away, the organ is speedily re-covered. In one curious case under my care, in which a jealous wife had unsuccessfully attempted to cut off her husband's penis with a carving-knife, the organ, which had had the whole of its integuments torn off from the root forwards, quickly became covered with a new integument, which speedily assumed the supple character natural to the skin of these parts.

When the penis is more deeply wounded, there are two special sources of danger, viz., hæmorrhage and wound of the urethra. The hæmorrhage is usually very profuse. If it proceed from a distinct arterial trunk, such as the dorsal artery or that of a corpus cavernosum, the vessel must be ligatured. If it occur from general oozing from the vascular tissues of the penis, it may be arrested by cold, pressure, or astringents. Pressure is best applied by passing a large catheter into the bladder, and then compressing the organ against this by means of a narrow bandage or circular strip of plaster.

Injury of the genital organs by self-mutilation is occasionally met with in cases of sexual mania or melancholia. In some cases the patient has cut off one testis; in others, the penis; in others, again, the whole of the external sexual organs. Injuries such as these present no very special characters, and require to be treated on ordinary principles, the great point being to restrain the hæmorrhage and to prevent contraction of the urethral orifice.

URETHRA.—**Wounds of the Urethra** by gunshot injury, or sharp instruments, is a troublesome accident, on account of the liability to the infiltration of urine and ultimately to fistula. It may be recognized by the escape of blood from the meatus, and of urine from the wound. The *Treatment* consists in the introduction of a catheter, which should be tied in: and if the edges of the wound be clean cut, they may be brought together by interrupted sutures. The catheter should not be kept in longer than is necessary. After the first week, the patient can in many cases be taught to pass a soft instrument for himself whenever he desires to pass water.

Laceration of the Urethra is immediately attended with most serious symptoms, and remotely followed by most disastrous consequences. It very frequently occurs in men employed in building, from slipping in walking across an unfinished floor, in such a way as to fall heavily astride upon one of the joists. I have seen it in a farrier, kicked in the perinæum whilst shoeing a horse; and it is not uncommonly met with as a consequence of injury by a fragment of bone in fracture of the rami of the pubes and ischium.

In all forms of the accident it is almost invariably the membranous part of the urethra that suffers. In a violent blow on the perinæum the urethra is forcibly driven upwards, and crushed against the pubic arch. When the laceration occurs from a fragment of bone in a fracture, it is usually in those cases in which the pelvis is forcibly compressed, and gives way both behind and in front (Fig. 206). The outer fragment is driven across the middle line in the perinæum, and thus tears the urethra. In both these accidents the inferior layer of the triangular ligament is torn; it is impossible that the membranous part of the urethra could be lacerated by a blow in the perinæum while it remained intact; and in the fracture it is torn at its attachment to the pubic arch; consequently if urine escapes from the urethra it readily finds its way into the loose areolar tissue beneath the deep layer of the superficial fascia.

In these injuries the integuments are usually untorn, but deeply ecchymosed. The extravasation of blood is often considerable, extending into the scrotum, which rapidly swells up and becomes black. It may, indeed, be very serious, arising in some cases from the lacerated structures and the torn superficial or transverse arteries of the perinæum; in other instances from the corpus spongiosum, the bulb, or the artery of the bulb. In all cases of lacerated urethra, blood will drip from the orifice; and, if the bulb and its arteries have

been torn, the hæmorrhage from these may be very great, a pint or more of blood being thus rapidly lost, in addition to great accumulations in the perinæum and scrotum, distending these parts with coagula.

In consequence of the interruption in the continuity of the canal and the compression or plugging of the torn part by coagula of extravasated blood, the urine cannot be voided and the bladder gradually fills. If the patient attempt to empty it, only a few drops will issue from the urethral orifice; but he will be seized with severe burning, smarting pain in the perinæum, and the ultimate evils of the injury will be greatly aggravated, for, wherever the urine penetrates, sloughing of areolar tissue will rapidly ensue. There is this great difference between extravasation of urine from ruptured bladder and from lacerated urethra: in the former case the urine escapes involuntarily from the injured organ; in the latter, no urine will escape from the torn urethra, unless by a voluntary expulsive effort on the part of the patient. The sufferings of the patient are speedily increased by retention of urine and the distress occasioned by distension of the bladder; and the necessity for relief thus becomes urgent, lest by an involuntary spasmodic effort the urine be pumped widely into the already broken-down areolar tissue of the perinæum.

The pathology and symptoms of extravasation of urine are fully described in the Chapter on Stricture of the Urethra. (See Vol. II.)

The ultimate results of a lacerated urethra are no less serious than the immediate effects. If the floor only of the urethra have been lacerated, leaving the upper part of the wall of the canal intact, the continuity of the urethra will not be lost, but a permanent traumatic stricture of the worst kind will ensue. If the urethra have been completely torn across, or slough as a result of the injury, obliteration of a portion of the canal may take place, and an incurable urinary fistula will be left in the perinæum.

The *Treatment* consists in the early introduction of a catheter into the bladder. If this can be done before the patient has made an attempt to pass his urine, much of the immediate danger of the case may be averted, by the prevention of urinary infiltration. The catheter, which should be an elastic one, must not be too small; as a rule, No. 8, English scale, will be found the most convenient size. A catheter coudé will often pass most readily, as the point is kept towards the roof of the canal which usually is uninjured. If this do not enter readily, an English gum-elastic catheter on a stylet bent to a proper form, various angles and curves being tried one after another, will often be successfully passed. No force must on any account be used; there is no resisting stricture to overcome; the passage is free enough if the right way in be found. When a catheter has been passed it must be left in for a week, or longer if it causes no irritation. It should not be plugged, but should have an india-rubber tube attached, so that the urine may readily escape. If any hardness, throbbing, or other sign of irritation occur in the perinæum, a free incision should be made into the part, so as to afford a ready outlet for any urine that may have been effused.

If the Surgeon find it impossible to introduce a catheter into the bladder, he should pass a grooved staff as far as it will go, and then, putting the patient in the lithotomy position, make a free incision in the middle line of the perinæum on to the end of the instrument. The seat of the laceration is freely exposed by holding apart the edges of the wound with retractors, clearing

away all blood-clot and arresting such hæmorrhage as may be still continuing. The staff is now withdrawn and a full-sized catheter passed along the urethra and guided if possible into the proximal end. This is often extremely difficult. If the floor of the urethra only have been torn, it may be accomplished by keeping the point of the catheter well against the upper wall of the canal; but if the urethra have been completely torn across, it will tax all the skill of the Surgeon to direct the instrument into the vesical end of the canal. Teale of Leeds recommends that a director should be first introduced into the proximal end of the opening in the urethra, over which a dilator may be passed; the director being then withdrawn, the catheter is readily introduced through the dilator. In some cases the difficulty appears to arise from the proximal end of the urethra being drawn upwards by the distended bladder. If this happens the bladder may be partially emptied by suprapubic aspiration. Should the Surgeon fail to introduce a catheter he will usually find that the urine drains away from the perineal incision, so that he can wait a day or two before making another attempt. It may however be found necessary to aspirate the bladder once or twice above the pubes. Failing all other means suprapubic cystotomy has been performed and the proximal end of the divided urethra found by passing a curved staff along it from the bladder. This is however a severe measure, to be avoided if possible. Suture of the urethra over a catheter should be practised, whenever practicable.

VAGINA AND RECTUM.—**Foreign Bodies** are occasionally thrust forcibly into or impacted in the vagina or rectum. When a foreign body, such as a stick, or a broom-handle, or the leg of a chair, is thrust forcibly up the rectum by a person falling on it, two injuries may result—extensive laceration of the sphincter ani and the perinæum, with hæmorrhage; or transfixion of the gut and wound of the peritoneum, with consecutive inflammation of that membrane, which almost invariably terminates fatally. The consequences of such an injury present nothing very special, and require to be treated on ordinary principles. If in the fall the foreign body have been forcibly thrust into the vagina, there may be injury to the bladder or peritoneum; but the most common source of danger is laceration of the labium, and free hæmorrhage from this source. I have several times seen enormous quantities of blood thus lost. This hæmorrhage is best arrested by plugging firmly with lint soaked in a solution of the perchloride of iron, and by the pressure of a bandage.

A variety of things, such as pieces of stick, glass-bottles, gallipots, tumblers, &c., have been introduced into and impacted in these canals. Their extraction is often very difficult, in consequence of the swelling of the mucous membrane over and around them, and the depth to which they have been pushed. In order to remove them, the use of lithotomy or necrosis forceps may be required. In some cases the foreign body produces ulceration into the bladder; and it has been found to transfix the wall of the canal in which it is lodged, and, by penetrating the peritoneum, has speedily caused death. A remarkable case of this kind occurred in my practice, in which a cedar pencil, five inches long, and cut to a point, had been forced up by the patient herself, a young woman, through the posterior wall of the vagina into the abdominal cavity. Here it transfixed two coils of the small intestine, and after being fixed there for eight months, I extracted it by an incision through the anterior abdominal wall, midway between the umbilicus and Poupart's ligament, where its point

was engaged in the fascia transversalis. It had occasioned repeated attacks of peritonitis; and, after extraction, death resulted from that cause.

Laceration of the Perinæum.—The perinæum is occasionally ruptured during parturition. The extent of the laceration varies greatly, and influences materially the ultimate issue of the case. In some cases there is merely a slight rent at the fourchette; in others, the whole perinæum has given way as far as the sphincter ani; in others the sphincter also is torn; or the rent may extend into the recto-vaginal septum. The worst cases are those in which the perinæum has been torn, and the recto-vaginal septum destroyed by sloughing from prolonged pressure of the fœtal head. In such cases, the loss of soft tissues and the existence of dense cicatricial bands render complete union by operation very uncertain. When the sphincter ani or the recto-vaginal septum has given way, incontinence of fæces forms the most troublesome symptom. The neighbouring parts are from this cause liable to excoriation; and not unfrequently the rectal mucous membrane becomes prolapsed or hæmorrhoidal.

The operation for the closure of ruptured perinæum is comparatively modern. Although it had been done in France by Guillemeau in the 16th century, and in this country by Smellie in the 18th, little attention was paid to the subject until Rouse, in 1834, published five cases, in four of which he had effected a cure by means of the quilled suture. From that time the operation took its place in surgery.

The operation may be done at two distinct periods after the occurrence of the laceration, viz., immediately or remotely.

Operation for Ruptured Perinæum.—The **immediate** operation is done as soon as possible after the occurrence of the accident. Anæsthesia is unnecessary except in those cases in which the tear is complete and passes into the rectum. The patient lying on the left side, the vagina is to be plugged with a sponge or a tampon of wool or gauze. The raw surface is then cleared of blood-clot, and closed with silver-wire or silkworm-gut sutures. These are introduced with a large fully-curved needle on a handle. The needle is made to enter the skin just beyond one lateral extremity of the raw surface, and passing across completely buried, emerges at a corresponding point on the opposite side; it is then threaded and withdrawn. Two or three sutures passed in this way are usually sufficient, and when all have been inserted the ends of each are twisted or tied together. The risk of perforating the anterior wall of the rectum during the passage of the needle may be obviated by introducing one finger into the bowel. In the more severe cases in which the sphincter ani is torn through, it will be necessary to employ additional sutures for the purpose of bringing together the ends of the muscle. These should consist of fine silver wire which can be passed with a half-curved needle. The needle is first introduced just to one side of the apex of the tear in the anterior wall of the rectum, accurately at the torn edge of the mucous membrane. It is passed forwards to a spot about half an inch from the point of entry; here it emerges into the wound, and being re-introduced at the corresponding point on the opposite side is carried backwards into the rectum in a similar manner. The ends are then twisted together, and other sutures are passed in the same way, each one being introduced rather further out and embracing a slightly greater extent of tissue than the preceding one. After the suturing has been completed the vaginal plug is removed. A vaginal douche of Condy's fluid or

boric acid lotion must be given twice daily. It is as a rule unnecessary to resort to the use of the catheter, provided that the parts be thoroughly cleaned and dried as often as they become soiled. The only dressing required is a small pad of antiseptic gauze or wool which should be changed frequently. The sutures may be left in position for a week or ten days.

The **remote** operation is undertaken for the cure of those cases in which healing has occurred without approximation of the parts by the immediate method above described. Of the very numerous operations which have been devised for this purpose, one of the simplest and most efficient is that recommended by Lawson Tait. The basis of the principle upon which Tait's operation is performed is that the thin white line of the cicatrix extends transversely to the axis of the rent, which was of course at right angles to the plane of the perinæum. The scheme of the operation "is to restore the old rent and unite it at right angles to its representative cicatrix—that is, at right angles to the plane of the perinæum." No tissue is removed, "and therefore if the operation fails the parts simply return to their abnormal state, not to one which is more unlikely to be remedied." The steps of the operation are briefly as follows, and are described almost in Tait's own words.

The folds of the buttocks being held firmly apart so that the cicatrix is put on the stretch, it is divided with scissors from end to end. The incision is about three eighths of an inch deep and forms two flaps, a rectal and a vaginal. From each end of the incision it is carried forwards into the tissue of the labium for about an inch, and again backwards beside the rectum for about a third of an inch. The vaginal flap is held forwards and the rectal flap backwards, so that the raw surface assumes a somewhat quadrilateral shape. Silk-worm-gut sutures are employed and are passed with a stout-handled and well-curved needle. Each suture is entered at a point about an eighth of an inch within the lateral margin of the wound, and emerges at the corresponding point on the opposite side. The needle is buried deeply in the tissues except at the upper angle of the wound where it appears on the surface. When a sufficient number of stitches have been passed they are tied, and thus the edges of the wound are drawn together in such a way that the resulting cicatrix is antero-posterior. Tait does not recommend the use of separate rectal sutures, but should the Surgeon think it advisable to use them, they may be inserted in the way described in the immediate operation. The sutures can be left in position for three or four weeks, and the rectum and vagina are washed out daily. The bowels should be opened at the end of a week by an aperient and a simple oil enema. The same remarks apply to the dressing of the wound and the use of the catheter as after the immediate operation.

DIVISION THIRD.

SURGICAL DISEASES.

DISEASES AFFECTING THE TISSUES GENERALLY.

CHAPTER XXX.

MORTIFICATION, OR GANGRENE.

THE death of a part of the body is, in surgical language, termed **Mortification** or **Gangrene.** In pathological language the term **Necrosis** is applied to local death generally, in whatever part or tissue it occurs; but in surgical practice it is customary to confine it to affections of the bones or cartilages: when limited to the soft tissues of a limb it is spoken of as **Sphacelation;** and when accompanied by ulceration, it is called **Sloughing.** Many other varieties of gangrene are recognized by Surgeons. Like most other diseases, it may be **Acute** or **Chronic** in its duration. As the parts affected are moist and swollen, or dry and shrivelled, it may be divided into the **Moist** and the **Dry** or **Mummified** gangrene; so again, according to its cause, it is spoken of as **Spontaneous** or **Traumatic;** and very frequently, it is arranged according to the nature of its cause under the denominations of **Constitutional** and **Local.** Besides these, various **Specific** forms of the disease are met with, which will require special consideration.

LOCAL SIGNS.—Certain local phenomena are common to all varieties of gangrene. The part becomes colder than natural, the temperature falling to that of the external air. Its sensibility is lost, and it may be touched, pricked, or cut without feeling. In some cases the sensibility is greatly increased just before gangrene sets in, agonizing pain of a burning or neuralgic character being experienced, which soon gives way to complete insensibility. The natural functions of the affected parts are abolished. Thus the muscles no longer contract, and all motion of the part itself ceases. The changes that subsequently take place in the tissues of the gangrenous part are of two kinds, giving rise to the division of gangrene into *dry* and *moist.* In the *moist* variety death of the part takes place while the tissues are engorged with blood, either from inflammation or from obstruction to the circulation through the veins or capillaries. In this form the skin of the dead part becomes discoloured, usually greyish or greenish, the

cuticle separates, and when pressed upon obliquely slides away under the finger, leaving the moist and slippery cutis exposed. The colour gradually darkens to a dull purplish greenish black, mottled in patches with reddish-brown spots; and after a time an odour of putrescence is evolved, very commonly with an emphysematous crackling from evolution of gas in the gangrenous tissues. This shows that putrefactive changes have taken place in the dead tissues. The *dry* variety occurs as a consequence of some obstruction to the supply of blood to the part, so that at the time it sets in the tissues contain less blood than natural. In it the colour is often at first of a pale tallowy white, mottled, with dusky spots. The skin soon becomes dry, horny, and semi-transparent, and eventually assumes a brown wrinkled appearance, and the whole gangrenous part becomes shrivelled and dry like the limb of a mummy.

Constitutional Symptoms.—These vary greatly. When the disease is strictly local, affecting a part of but limited extent, and perhaps of no great importance to the economy, they are not very strongly marked. If, however, the gangrene, although limited, implicate important organs, as a knuckle of intestine for example, marked symptoms declare themselves.

The full invasion of the gangrene, if it affect any considerable extent of tissue or any important organ is always attended with great depression of the system. The countenance is dull and anxious and the pulse feeble, quick, and easily compressible; the tongue is brown, and the lips and teeth loaded with sordes. In moist gangrene the constitutional disturbance is aggravated in some cases by absorption of the products of the unhealthy inflammation from which the death of the part has resulted, and in others of the products of putrefaction from the decomposing slough. Death may in fact occur from this cause with all the symptoms of septic poisoning. In dry gangrene these symptoms are usually much less marked. When gangrene affects an internal organ the depression is always very great, and the special symptoms will vary with the part affected.

Causes.—The causes of gangrene are *predisposing* and *immediate*. Anything that tends to lower the vitality of the tissues must necessarily bring them into a state in which a comparatively slight injury may cause their death. These conditions have already been fully discussed in the chapter on inflammation (p. 172 *et seq.*). The predisposing causes of inflammation, when acting more powerfully, predispose to gangrene.

Immediate Causes of Gangrene.—These may be divided thus:—

1. **Causes acting primarily by arrest of the Circulation.**—These may again be divided into:—

(*a.*) *Arrest of the Supply of Arterial Blood to a part.*—This is a common cause of gangrene. It may be produced by accident, by ligature or other surgical operation, or by thrombosis or embolism of the arteries.

(*b.*) *Obstruction of the Circulation through a part.*—This is seldom a primary cause of gangrene, and as such arises only from pressure either from within, as from the growth of a tumour, or from without, as in the formation of bed-sores or sloughs beneath splints. Obstruction to the capillary circulation necessarily accompanies all acute inflammations, and often forms an important element in the production of gangrene; but in inflammation it is not a primary cause, being secondary to the damage done to the tissues directly by the irritant causing the inflammatory process.

(*c.*) *Obstruction to the Return of Venous Blood from a part.*—This seldom forms the sole cause of gangrene, even when important veins are occluded by thrombosis or pressure. As an accessory cause, it frequently aids in the production of gangrene, when the main artery is obstructed at the same time.

(*d.*) *Diminished Vis a Tergo from extreme weakness of the heart's action.*—This is a powerful accessory cause when there is any obstruction either to the arterial flow or to the venous return. It may result from extreme debility from fever or from starvation. The gangrene that accompanies ergot-poisoning is supposed to be due partly to relaxation of the veins by which a large quantity of blood is withdrawn from the circulation, and partly to weakness of the heart's action. Great loss of blood may in the same way aid in producing gangrene.

2. **Causes acting directly on the Tissues:—**

(*a.*) *Traumatic Causes.*—The production of gangrene by mechanical violence, heat and cold, and caustic fluids has already been fully discussed, and needs no further notice here.

(*b.*) *Causes giving rise to acute inflammation.*—Any acute inflammation as already pointed out in the chapter on inflammation, may terminate in gangrene, if the irritant which causes it is of sufficient intensity or the tissues upon which it acts are of abnormally low vitality.

In certain forms of specific infective inflammation gangrene forms the principal characteristic of the process, as in hospital gangrene, cancrum oris, carbuncle, malignant pustule, and spreading traumatic gangrene.

Amongst the causes, some are **Constitutional**, others **Local**, in their action. Those forms of gangrene are said to be *constitutional* which arise from obstruction of the circulation in consequence of disease of the heart and vessels. The constitutional state also frequently forms an important predisposing cause of gangrene in cases in which the immediate cause is local. Bright's disease and diabetes are amongst the most frequent conditions which act in this way. Those varieties of gangrene are *local* which arise from injuries of all kinds, whether applied to the part itself, or to the main artery leading to it, by its ligature or wound.

The forms of gangrene which arise from traumatic causes, have already been described in previous chapters (see pp. 336, 404, 461); while those that are due to obstructed circulation to or through a part, or that take the form of specific disease, are left for consideration here.

Gangrene from Arrest of the Supply of Arterial Blood.—Whenever a part of the body is deprived of its proper supply of blood, mortification may ensue. Most commonly when the principal trunk of an artery is obstructed, the collateral circulation is sufficient to maintain the vitality of the part; but, should this be interfered with, gangrene results. Indeed, the sudden loss of a large quantity of blood from the system may occasion the death of some of those parts in which the circulation is naturally most languid. Thus Brodie relates the case of a drunken man, who, being bled to an inordinate extent, was seized with gangrene of both feet.

Obstruction to the flow of blood through the arteries may be occasioned by two primary sets of causes:—*a*, from *injury* or *operation*, as wound or ligature of the main trunk; *b*, from *disease*, as by *thrombosis* and *embolism*, or by *calcification, and subsequent occlusion of the vessel.* Gangrene from arterial

cuticle separates, and when pressed upon obliquely slides away under the finger, leaving the moist and slippery cutis exposed. The colour gradually darkens to a dull purplish greenish black, mottled in patches with reddish-brown spots; and after a time an odour of putrescence is evolved, very commonly with an emphysematous crackling from evolution of gas in the gangrenous tissues. This shows that putrefactive changes have taken place in the dead tissues. The *dry* variety occurs as a consequence of some obstruction to the supply of blood to the part, so that at the time it sets in the tissues contain less blood than natural. In it the colour is often at first of a pale tallowy white, mottled, with dusky spots. The skin soon becomes dry, horny, and semi-transparent, and eventually assumes a brown wrinkled appearance, and the whole gangrenous part becomes shrivelled and dry like the limb of a mummy.

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(*b.*) *Obstruction of the Circulation through a part.*—This is seldom a primary cause of gangrene, and as such arises only from pressure either from within, as from the growth of a tumour, or from without, as in the formation of bed-sores or sloughs beneath splints. Obstruction to the capillary circulation necessarily accompanies all acute inflammations, and often forms an important element in the production of gangrene; but in inflammation it is not a primary cause, being secondary to the damage done to the tissues directly by the irritant causing the inflammatory process.

(*c.*) *Obstruction to the Return of Venous Blood from a part.*—This seldom forms the sole cause of gangrene, even when important veins are occluded by thrombosis or pressure. As an accessory cause, it frequently aids in the production of gangrene, when the main artery is obstructed at the same time.

(*d.*) *Diminished Vis a Tergo from extreme weakness of the heart's action.*—This is a powerful accessory cause when there is any obstruction either to the arterial flow or to the venous return. It may result from extreme debility from fever or from starvation. The gangrene that accompanies ergot-poisoning is supposed to be due partly to relaxation of the veins by which a large quantity of blood is withdrawn from the circulation, and partly to weakness of the heart's action. Great loss of blood may in the same way aid in producing gangrene.

2. **Causes acting directly on the Tissues :**—

(*a.*) *Traumatic Causes.*—The production of gangrene by mechanical violence, heat and cold, and caustic fluids has already been fully discussed, and needs no further notice here.

(*b.*) *Causes giving rise to acute inflammation.*—Any acute inflammation as already pointed out in the chapter on inflammation, may terminate in gangrene, if the irritant which causes it is of sufficient intensity or the tissues upon which it acts are of abnormally low vitality.

In certain forms of specific infective inflammation gangrene forms the principal characteristic of the process, as in hospital gangrene, cancrum oris, carbuncle, malignant pustule, and spreading traumatic gangrene.

Amongst the causes, some are **Constitutional**, others **Local**, in their action. Those forms of gangrene are said to be *constitutional* which arise from obstruction of the circulation in consequence of disease of the heart and vessels. The constitutional state also frequently forms an important predisposing cause of gangrene in cases in which the immediate cause is local. Bright's disease and diabetes are amongst the most frequent conditions which act in this way. Those varieties of gangrene are *local* which arise from injuries of all kinds, whether applied to the part itself, or to the main artery leading to it, by its ligature or wound.

The forms of gangrene which arise from traumatic causes, have already been described in previous chapters (see pp. 336, 404, 461) ; while those that are due to obstructed circulation to or through a part, or that take the form of specific disease, are left for consideration here.

Gangrene from Arrest of the Supply of Arterial Blood.—Whenever a part of the body is deprived of its proper supply of blood, mortification may ensue. Most commonly when the principal trunk of an artery is obstructed, the collateral circulation is sufficient to maintain the vitality of the part ; but, should this be interfered with, gangrene results. Indeed, the sudden loss of a large quantity of blood from the system may occasion the death of some of those parts in which the circulation is naturally most languid. Thus Brodie relates the case of a drunken man, who, being bled to an inordinate extent, was seized with gangrene of both feet.

Obstruction to the flow of blood through the arteries may be occasioned by two primary sets of causes :—*a*, from *injury* or *operation*, as wound or ligature of the main trunk ; *b*, from *disease*, as by *thrombosis* and *embolism*, or by *calcification, and subsequent occlusion of the vessel.* Gangrene from arterial

obstruction varies materially in its symptoms, prognosis, and treatment, according as it arises from one or other of these causes. When the obstruction in the arteries is very complete, the gangrene will be of the dry kind; but if some blood still finds its way into the part, and if there is at the same time an impediment to the return of blood through the veins, the disease will partake more or less of the characters of the moist variety.

(*a.*) A limb gangrenous in consequence of the **Ligature or Wound of its Main Artery,** without any other injury to the vascular system, becomes cold, feels heavy, and loses its sensibility; at the same time it assumes a dull tallowy white colour, mottled with greyish or brownish streaks. This state of things is met with chiefly in the lower extremity. In a short time the pallid colour is lost, the part becoming brown or blackish; the integuments of the foot become semi-transparent and horny-looking where they are stretched over the tendons of the instep, and the part presents a shrivelled appearance. This form of gangrene may invade the whole of the lower limb, but most commonly is limited to the foot, stopping either just above the ankle, or if not there, immediately below the knee, as Guthrie has observed; the arrest taking place in one or other of these two spots, on account of the greater freedom of the collateral circulation here than in other parts of the limb. If any of the large venous trunks become obstructed or otherwise implicated, so that the return of blood through them is interfered with at the same time that the supply by the arteries is arrested, the limb generally assumes a greenish-blue colour, and rapidly runs into putrefaction. In some of these cases it happens that sloughs of the integument and subcutaneous areolar tissue form, although the limb generally preserves its vitality. The treatment of these forms of gangrene, which are strictly local, is described in the chapter on the Arrest of Arterial Hæmorrhage.

(*b.*) Gangrene may occur from the arrest of the circulation through an artery as the result of *disease of the coats of the vessel.* This is the variety that is commonly called *spontaneous.*

Spontaneous gangrene is termed **Senile** when it occurs in old people in consequence of the arteries becoming rigid and their calibre narrowed by **Atheroma or Calcification of their Coats.** The pathology of these affections of the arteries will be more fully discussed in the chapter on Diseases of the Blood-vessels in Volume II. It is sufficient here to state that these changes render the arteries unable to maintain the proper circulation of blood through the limb, and further from the roughening of the inner coat predispose them to thrombosis, that is to say, to the deposit of fibrin by which the vessel may become completely obliterated. The want of a due supply of arterial blood in these cases is owing not only to the diseased state of the arteries, but also in a great measure to the weak propulsive power of the heart, and the consequent feebleness of the circulation especially through the lower limbs. When the circulation is so far interrupted as to lower the nutrition of the limb, the following premonitory symptoms are observed. The patient complains of a sensation of weight in the limb, with coldness, itching, and tingling in the foot, and cramps in the calf. The circulation of the part is habitually defective, the pulsation of the tibials being scarcely perceptible. In some cases cutaneous ulcerations ensue. These symptoms commonly exist for a considerable length of time before gangrene actually comes on, and should always be looked upon with anxiety in old people.

When the circulation becomes arrested from the conjoined influences of diminished cardiac power and arterial obstruction, gangrene inevitably results. It is met with in the lower extremities of people past the middle period of life, and the tendency to it increases as age advances.

Senile gangrene may set in in different ways. In many instances it commences without any apparent exciting cause. The toes and foot simply shrivel, without any sign of local inflammation and with but little constitutional disturbance. The part that is destroyed becomes black, dry, and shrunken, resembling in appearance the limb of a mummy; hence the change is often termed **Mummification** (Fig. 336). The toes often look like the shrivelled skins of over-ripe or sucked-out black grapes. This form of gangrene is usually due to the complete occlusion of a previously diseased artery by thrombosis.

Fig. 335.—Popliteal and Tibial Arteries obstructed by Thrombosis.

In other cases the gangrene is the immediate result of some slight inflammation accidentally induced, as from the excoriation produced by a tight boot, or from a trivial wound in cutting a corn or toe-nail. In these cases the slight injury, which in healthy tissues would be harmless, causes the formation of a small slough. This decomposes, and the products of putrefaction acting on the surrounding tissues give rise to a spreading inflammation, which, owing to the greatly diminished vitality of the part, terminates in gangrene, and the process thus started may spread until it reaches tissues of sufficient vitality to resist its progress. In other instances, again, the disease is ushered in by more acute symptoms. The whole foot becomes swollen, œdematous, and red; inflammation, apparently of a gouty character, being set up in it. The gangrene may at first affect only one toe, or it may from the commencement involve several toes. It generally begins as a purple or blackish-red spot on the side of one of the toes, usually the inner side of the great toe; this spot may be surrounded by an inflamed areola, and accompanied by much smarting and burning pain of a paroxysmal character; it spreads by gradually involving the inflamed areola, which continues to extend in proportion as the gangrene progresses. The pain, which is often of the most intense character, subsides when the gangrene becomes complete.

Fig. 336. — Senile Gangrene: Exposure of Bones of Foot.

In whichever way the gangrene commences the affection gradually extends, invading perhaps one toe after another, involving the instep (Fig. 336), or the sole of the foot and the heel; and unless it terminate by the formation of the line of demarcation, or death put an end to the patient's sufferings, it may extend up to the ankle or leg. In other instances, the gangrene being limited to a small extent, as to the toes only, the patient may recover with the loss of the fore part of the foot.

The constitutional symptoms vary with the mode of invasion. In the

inflammatory form there is usually considerable constitutional disturbance with some fever at first, subsequently sinking into marked depression with subnormal temperature as the patient becomes poisoned by absorption of the products of putrefaction; and the disease may thus often prove fatal in from a month to six weeks. On the other hand, in the dry form of gangrene, I have known the disease to continue with very little constitutional disturbance for more than twelve months, slowly creeping on during that time. In all forms of spontaneous gangrene there is a marked improvement in the constitutional state as soon as a distinct line of demarcation forms between the dead and the living tissues.

The thin skin on the anterior part of the leg at its middle and lower third is apt to fall into a state of gangrene in old people as the result of very slight injuries, and occasionally without any obvious external cause. In these cases a bleb forms which on breaking leaves a slough which gradually dries, becomes black and extends as the neighbouring parts are killed by a process of painful inflammation.

Diabetes is a fertile cause of gangrene of the toes and feet. It most commonly occurs in middle-aged well-nourished diabetics, and is rarely met with in the acute form of the disease in young subjects. Diabetes is associated with a general state of malnutrition of the tissues, but it is probable that this alone is never the cause of gangrene, although it favours the spread of the disease when it has once started. Cellulitis is especially liable to follow slight wounds in patients suffering from diabetes, and in some cases this is the starting point of the gangrenous process. Further, it has been shewn by Billroth, Frerichs and others, that diabetes is frequently associated with extensive arterial degeneration. This is undoubtedly a most important element in the causation of diabetic gangrene, which is thus closely allied to senile gangrene, differing chiefly in its greater tendency to spread on account of the unusually feeble vitality of the tissues. Lastly, it is now recognised that diabetes is occasionally a cause of peripheral neuritis, and this may be one element at least in the production of gangrene, particularly of the slowly-spreading variety which begins in a perforating ulcer similar to that occurring in locomotor ataxy.

The disease usually commences with a large bleb which forms on the under surface of the foot or at the end of one of the toes. This bleb contains fluid which speedily becomes turbid, and is surrounded by a dusky purple areola. From this the gangrene slowly spreads, and unless the diabetes can be checked, may largely invade and destroy the foot.

Thrombosis of an artery (Fig. 335) occurs only as a consequence of previous disease of its inner coat, so, although it is frequently the immediate cause of gangrene, by obstructing an atheromatous or otherwise diseased vessel, it is never the primary cause of the disease.

Embolism is more frequent as an immediate cause of gangrene. An embolus is a solid body, which, having entered the circulation, is carried onwards by the blood-stream until it lodges in some vessel which is too narrow to allow it to pass. Emboli, if of any size, almost invariably lodge at the point at which a main trunk bifurcates or gives off a large branch. If very small they may pass on into the capillaries, causing capillary embolism. When an embolus has lodged in an artery, a clot forms upon it, reaching as high as the first branch above the point of obstruction. Fibrin which has been deposited

upon a diseased part of a large vessel, or in a fusiform aneurism, and vegetations from the valves of the left side of the heart, are the most common sources of embolism in the systemic arteries; but occasionally a fragment of a tumour which has penetrated the coats of a large artery may be washed away into the blood-stream and form an embolus.

Gangrene from embolism is most common in the lower limb, and the bifurcation of the popliteal artery is the usual place at which the embolus lodges. If it be so small as to pass into one of the tibials, the circulation is maintained by the unobstructed artery; and gangrene does not occur. Gangrene from embolism is, however, also met with in the upper limb. In these cases the gangrene develops suddenly, the whole of the parts deprived of blood perishing simultaneously, there being no tendency for the mischief to spread; pulsation ceases in the terminal branches of the obstructed artery, and intense superficial pain is felt in the limb, ceasing after about a week. The limb is at first pale, but soon undergoes the characteristic changes in colour, when decomposition commences. The gangrene is always of the dry variety. In the leg, as Billroth points out, the foot soon becomes mummified, while near the line of demarcation the parts remain more moist. The line of demarcation forms in these cases immediately below the knee. Gangrene from embolism may prove fatal from septic poisoning before any attempt can be made by nature to separate the mortified part. After death, the affected vessel is found firmly plugged by the embolus, above which is a dense coagulum reaching as high as the next branch.

Fig. 337.—Obstruction of Femoral Artery at its Bifurcation by an Embolus and ascending Thrombosis.

The accompanying drawing (Fig. 337) represents the bifurcation of the common femoral artery occupied by a fibrinous plug, taken from a man aged 32, who died of gangrene of the left leg. In this case the patient, after recovering from rheumatic endocarditis, whilst straining at stool, suddenly felt his left leg tingle painfully, then become numb and cold. The circulation in it ceased, and gangrene speedily supervened, which extended as high as the knee. Death followed amputation of the limb. Here there can be little doubt that the sudden supervention of gangrene was the result of obstruction to the arterial circulation of the lower extremity, consequent on the detachment of a vegetation from the valves of the heart, and its arrest at the bifurcation of the femoral artery.

In addition to the varieties of spontaneous gangrene just described, some other rarer forms are occasionally met with. Von Winiwarter has described a peculiar form of overgrowth of the endothelial cells of the inner coat of both arteries and veins—**endarteritis and endophlebitis proliferans**—by which their lumen becomes obliterated. Thrombi are formed in the affected vessels, and these become organized and penetrated by new vessels, as in the closure of a ligatured artery. This affection is said to be caused by syphilis and alcoholism, and occurs usually at an earlier age than ordinary senile gangrene. According to Billroth the signs of imperfect blood-supply may be present for some years before gangrene takes place. When gangrene does set in, it is usually of the moist variety. Examples of gangrene of this variety are described in Chap. XLII.

Raynaud has described a rare form of **symmetrical gangrene** which attacks

the fingers, and sometimes the toes. The premonitory symptoms are that the fingers readily become "dead," often from very slight exposure to cold, and are slow in recovering. In the more advanced conditions the fingers become of a livid colour, cold and insensitive, but intensely painful, a condition described by Raynaud under the name of "local asphyxia." This may pass off after a few hours, and the circulation may be restored, or a bleb may form at the end of one or more of the fingers, beneath which a slough is found when the cuticle is removed, or in extreme cases the whole ungual phalanx may become mummified. The corresponding fingers of the opposite hand may be affected simultaneously or at a later period. The affection is most common in women between 18 and 30. It resembles severe chilblains in some respects, but differs in the intensity of the pain, the character of the gangrene, and the age of the patient. In some recorded cases there has been a history of ague; it is occasionally associated with paroxysmal hæmoglobinuria. It is supposed to be due to vaso-motor disturbance consequent upon central mischief situated in the cord; but its pathology is uncertain.

Gangrene from Venous Obstruction.—Obstruction to the veins by pressure or thrombosis is scarcely ever the sole cause of gangrene; but if at the same time the main artery is occluded, as when it and the vein are compressed together, or when the femoral vein is wounded accidentally at the time when the artery is ligatured, mortification is especially apt to take place. Gangrene from this cause is always of the moist kind, attended with much œdema, discoloration, and rapid putrefaction of the part.

Gangrene from arrest of the Circulation by Strangulation.—A part is often purposely strangled by a Surgeon in operative procedures; or its circulation may in this way be arrested as the result of certain accidents or diseased conditions. (See p. 313.) In either case, the strangulation acts by stopping more or less completely the whole of the circulation through the part. If the strangulation be sufficiently severe, it may kill the tissues outright: for instance, when a nævus or a pile is tied, all flow of blood to or from the part is suddenly arrested, and its vitality is destroyed, the tissues that have been strangled shrivelling and separating by ulceration along the line of ligature. When the strangulation is not so severe as this, great congestion ensues, consequent on the amount of blood sent into the part being greater than can escape by the veins, which are more affected by the constricting force than the arteries; the part strangled becomes dark and congested, and effusion takes place into its tissue. If it be a superficial part, blebs arise on the skin. As the part swells the compression of the vessels becomes more powerful, till finally the flow through the arteries is arrested as well as that through the veins; the circulation is completely stopped, and thus sloughing arises. All this we find in the constricted gut in a strangulated hernia.

Gangrene as a termination of Inflammation.—It has already been pointed out (see the chapter on Inflammation) that all the causes of inflammation are agents which tend to lower the vitality of the parts upon which they act, and that, if acting with sufficient intensity, they bring the process of inflammation to an end by killing the tissues upon which they are exerting their influence. The effect produced by an irritant is dependent: first, on the intensity of the irritant itself; secondly, in many cases on the duration of its action; and thirdly, on the power of resistance, or in other words, on the

vitality of the tissues upon which it is acting. Thus, to take an example, a mustard plaster if applied for a short time on a healthy part causes simple inflammation without destruction of tissue; if it be of sufficient strength and be kept on a longer time, it will cause death of the skin upon which it is acting. Supposing it, however, to be applied to the skin of a part, the vitality of which is lowered either by constitutional causes of mal-nutrition, such as diabetes or Bright's disease, or from local interference with nutrition, or from degeneration of the arteries, sloughing may result. It has also been pointed out that an irritant of sufficient intensity causes arrest of the circulation, by stasis, in the vessels of the part upon which it acts, and that this condition, unless relieved, must terminate in gangrene. Lastly, all acute inflammations are attended with migration of leucocytes, with abundant coagulable exudation, which distends the lymph-spaces, and presses on the vessels of the inflamed part, thus still further impeding the circulation through it. In gangrene as a termination of inflammation there are thus three causes involved: first, the direct injury done to the tissues, including the walls of the vessels, by the irritant which causes the process; secondly, obstruction to the circulation from within by stasis; and thirdly, obstruction from without by the pressure of the inflammatory exudation.

The relative part taken by these different causes varies in different forms of gangrenous inflammation. In some the irritant that causes the process is so powerful in its action, or as it is more commonly expressed in clinical language, the intensity of the inflammation is so great as to kill the part almost directly, however healthy its texture or sound the constitution of the patient may be. More commonly, however, it is not so much the actual as the relative intensity of the inflammation that destroys the part; there being some debility, local or constitutional, by which the resisting power is lessened. Thus gangrene arises especially in persons whose tissues have degenerated in consequence of old age, defective food, or habitual intemperance. It is remarkable to observe what slight injuries will induce gangrenous inflammation under these circumstances. The nature of the tissue also exercises considerable influence: thus areolar tissue and fasciæ slough more readily than the skin or muscles, whilst the proper tissue of glands is seldom affected. As a rule, the least vascular tissues slough most readily. The pressure of the exudation exerts a marked influence in many forms of spreading gangrenous inflammation of the areolar tissue. Thus in phlegmonous erysipelas free incisions may avert the danger of sloughing of the skin and subcutaneous tissue by relieving tension and allowing a ready exit for the inflammatory exudation.

Gangrene may form the termination of inflammation arising from simple mechanical, physical, or chemical irritants. It is then localized, and has little tendency to spread beyond the area directly injured. It is much more frequently met with as a characteristic feature of certain forms of infective inflammation, as in phlegmonous erysipelas, sloughing phagedæna, hospital gangrene, spreading gangrene, cancrum oris, or malignant pustule. The special features of infective inflammations have been already pointed out (p. 183 *et seq.*). In the gangrenous forms of infective inflammation, death of the tissues may be due directly to the intensity of the virus, as in hospital gangrene, in which the parts are destroyed as if by the action of a powerful caustic; or to the disturbance of the circulation by the extent and abundance

of the exudation, as in phlegmonous erysipelas, in which, if free vent be provided and tension relieved by incision, the death of the tissue may be prevented. Some forms of gangrenous inflammation are intensely contagious, as hospital gangrene; others, as malignant pustule, are communicable solely by inoculation; and others again, as cancrum oris, although having the characters of an infective inflammation, are not capable of being carried from one patient to another.

Gangrene consequent on inflammation is of the moist or acute kind, being always connected with a retention of blood in the part affected. We may regard it as impending in a part that has become inflamed from injury or other cause, if we find that the redness becomes of a dusky or purplish hue; that bullæ filled with dark fluid rise upon the surface; that the swelling, at first hard, tense, and brawny, becomes of a pulpy or doughy character; that the pain is of a dull, heavy, or burning kind; and that the temperature of the part, at first greatly increased, gradually sinks. We know that gangrene has taken place when there is a total loss of the sensibility of the part, even to pricking or pinching; that the motion of the part itself ceases; that its colour changes to a peculiar mottled, purplish-red, or greenish-black hue, unlike anything else in the body; and that the temperature falls to a level with that of the surrounding air. There is likewise an extremely offensive odour evolved differing from that of ordinary *post-mortem* decomposition.

The *Constitutional Symptoms* are always those of fever, with marked depression, often assuming the character of septic poisoning.

ARREST OF GANGRENE.—Certain forms of gangrene consequent upon infective inflammatory processes have a tendency to extend indefinitely until the patient succumbs to the disease. In all forms of spontaneous gangrene, and in that due to direct injury to the tissues, the progress of the mortification is in most cases arrested, and the dead parts are separated from the living. When the gangrene reaches a part of which the vitality is too great to be destroyed by the operation of the causes which have produced death in the tissues beyond, **a line of demarcation** is formed. The process by which the separation of the dead from the living tissues is accomplished has been fully described in the chapter on Ulceration (see p. 271). The dead parts are not thrown off merely by disintegration, but by a vital process, that of ulceration, occurring in the living tissues. The line of ulceration is termed the **line of separation**, and extends along the extreme margin of the living tissues (Fig. 338).

Fig. 338.—Senile Gangrene of Foot: Line of Separation.

This process of separation, commencing at the edge of the slough, slowly extends downwards to the whole depth of the gangrene; if this affect the entire thickness of the limb, the ulceration will find its way completely across it. If the slough be more superficial, the ulceration extends beneath it, and detaches it gradually. The line of separation is usually oblique, the soft parts being first divided, and the hard tissues then ulcerated through, until the ligamentous or osseous structures, which are slowly acted upon,

are severed. As the ulceration extends across the limb, the largest arteries and veins are cut through by it, without the occurrence of hæmorrhage, owing to the thrombosis, which blocks them from the line of separation to the nearest large collateral branch above it. The period required for the detachment of gangrenous parts varies according to their extent. Small sloughs may be detached in a few days, whilst many weeks are required for the separation of a limb. The action is most rapid in soft vascular tissues and in young subjects. After the separation of the gangrenous part, a more or less irregular ulcerated surface is left, which, if not too extensive, and if the patient's reparative powers are in a favourable state, will cicatrize by the same process as ordinary ulcers.

Diagnosis.—The diagnosis is readily made when gangrene is fully developed; but in the early stages, before it is positively declared, it is not always easy to determine its existence. The ecchymosis and discoloration of a bruise, the collapse and lividity that result from cold, or the dark purple hue occasioned by long-continued congestion, may readily be confounded with impending gangrene. In these cases of doubt, the Surgeon should not be in too great a hurry to pronounce an unfavourable opinion, and still less to act upon it; for not uncommonly parts of the body which have to all appearance lost their vitality, may, under proper treatment, regain it.

Prognosis.—The prognosis as to the part itself is always bad; though occasionally, when gangrene has not been fully established, partial recovery may unexpectedly take place. So far as the life of the patient is concerned, much will depend on the cause of the affection, and on the age and strength of the individual; at advanced periods of life, and in a feeble state of system, the result is always unfavourable. Also whilst the gangrene is spreading, the prognosis is bad, as it is impossible to say where the morbid process may stop; but when a "line of demarcation" has formed, indicating the possession of a certain vigour of constitution, the principal danger is over, and the result will depend on the strength of the patient, and the support that can be given during the processes of separation and of repair.

Treatment.—As gangrene proceeds from a great variety of causes, it is evident that no one plan of treatment can be universally applied; and it becomes necessary to modify our therapeutical and operative measures, not only according to the cause of the disease, but also with reference to the constitution of the patient, and to the stage in which we meet with the gangrene; and, indeed, it often requires great experience to accommodate the treatment to the varying phases of the disease.

The **Constitutional Treatment** of gangrene is of the highest importance, more especially in the spontaneous forms of the affection. It has three principal aims: 1. To *remove the cause* if possible, and thus to *arrest the gangrene*. 2. To *support the powers of the system during the process of the separation of the dead tissues*; and 3. To *lessen the irritability of the nervous system*.

1. In attempting *to remove the constitutional cause* we must bear in mind that constitutional conditions most commonly act only as predisposing causes of gangrene, the death of the part being determined by some local affection. The constitutional conditions which predispose to gangrene, such as want of food, diabetes, Bright's disease, fevers, feebleness of the heart's action, or general arterial degeneration, are all associated with debility. Depressing

remedies must therefore be avoided even in the inflammatory forms of the affection.

Inflammatory fever, however high it may be in the early stages, rapidly gives way, after gangrene has set in, to symptoms of an asthenic type. It is only before the occurrence and during the spread of gangrene, that the use of lowering remedies could possibly be suggested; for, when once gangrene has ceased to extend, however high the fever may have been that accompanied its progress, all the powers of the constitution will be required to maintain the process of separation of the sloughs, if they be extensive and deep. Venesection is never required in any form of gangrenous inflammation. In the forms of gangrene consequent upon specific infective inflammation, however acute the symptoms may be, depletion is never necessary. It would only render the tissues less able to withstand the effects of the specific irritant which is causing the process. In all inflammatory forms of gangrene the diet should be light but nutritious; and the patient should be put to bed, with the affected part elevated, and in many cases a brisk purgative at the commencement of the treatment enables him to take his food better. As the disease advances mild tonics may be given, and in the later periods, when the constitutional symptoms become asthenic, stimulants should be administered. The best stimulants are wine or porter, according to the patient's habits of life; and these should be given in combination with nourishment, so as not merely to raise the pulse, but to produce a more permanent tonic influence on the system generally. If much depression occur, the medicinal stimulants, especially ether, ammonia, and camphor, are of material service. The only tonics that are of much value here are the preparations of cinchona bark and some of the vegetable bitters, as gentian and cascarilla; and though the specific virtues that were formerly attributed to them can no longer be accorded, yet when they do not irritate the stomach, they are of unquestionable service in combating the asthenic symptoms, and improving the digestive powers. In these cases I look upon cinchona bark, in combination with chlorate of potash and ammonia, as of undoubted value.

As a great part of the constitutional disturbance in most cases is due to the absorption of the products of putrefaction from the dead tissues, much can be done to relieve the symptoms by the efficient local use of antiseptics.

2. After the proper employment of means calculated to remove the constitutional cause of the gangrene, the *system must be supported against the debilitating influences that accompany the process of ulceration and of suppuration* necessary for the separation of the mortified parts. During this period, there is less fever but more debility, and stronger tonics and stimulants can be borne; but we should be careful not to overstimulate the patient. On this point it is extremely difficult to lay down any precise rule; every possible variety as to the quantity and quality of food and stimulant being required by different individuals. The safest guides are the state of the pulse and tongue; if they improve, the means employed agree. At the same time hygienic measures should be carefully attended to; cleanliness and free ventilation, with the abundant use of disinfectants, are of the first importance.

3. The third indication, that of *lessening the irritability of the system* which always supervenes, and which is partly owing to the severity of the pain, and partly to the shaken and depressed state of the nervous system, is best carried

out by the administration of opium; and although this drug may not act as a specific, as Pott supposed, yet in many cases, and especially in the gangrene of the toes and feet of old people, it is undoubtedly a remedy of the greatest value. A grain of solid opium may advantageously be administered every sixth, eighth, or twelfth hour, according to the effect which it is found to produce; care being taken that the bowels do not become confined. The hiccup, which is often depressing, is best remedied by the administration of spirits of chloroform and camphor. The effect of opium in diabetic gangrene is often most striking. It must be given in the largest amount the patient can bear, and in most cases as soon as the patient is fully under its influence, the progress of the disease ceases.

Local Treatment.—Gangrene, when threatening as the result of inflammation, may often be prevented by free incisions into the inflamed and tense tissues. Punctures are not sufficient, but free incisions two or three inches long, should be made, which by gaping widely allow the escape of blood and other fluids, and thus effectually relieve the vessels and the tissues. This is more especially the case where there is much loose areolar tissue, as in the penis or scrotum; or indeed in any part in which much tension results from the inflammation. The *relief of local tension* is of the first importance in cases of inflammation threatening to terminate in gangrene. By a free incision through the structures so affected, as in phlegmonous erysipelas, not only may the vitality of the affected tissues be preserved, but the extension of gangrene, if it have already set in, may be arrested, and the constitutional disturbance at once lessened. By incision, also, irritating effusions and infiltrations are discharged, and thus one cause of sloughing is removed.

In the non-inflammatory form of the disease, as soon as it is evident that a part is about to become gangrenous it should be carefully washed with warm carbolic acid lotion (1 in 40). This solution is not of sufficient strength to cause any irritation of the unbroken skin. Having thus rendered the surface as far as possible aseptic, the whole limb should be thickly wrapped in salicylic wool, or it may be sprinkled with iodoform and afterwards covered with iodoform-wool. By this treatment offensive decomposition may often be prevented. Carbolic acid dressings should not be applied, as they are too irritating and might cause extension of the mischief. The dressing should not be disturbed unless the smell indicates that decomposition is taking place beneath it. At a later stage the same treatment may be continued, or the parts that are already gangrenous may be enveloped in lint soaked in warm solutions of carbolic acid, boric acid, chloride of zinc, or creasote, or they may be dusted with charcoal powder and covered with a layer of wadding. No poultices should be applied if the sloughs be large, for heat and moisture hasten decomposition. *The separation of the sloughs* should be left as much as possible to nature. The vitality of the tissues in the proximity of and above the line of separation is very low, and may readily be destroyed by any operative interference. Hence no attempt should be made to remove sloughs not already separated, nor should stimulants be applied to the living tissues. It matters little what is done to parts already dead, which, when loosened, may be cut away; but we must not meddle with those that are living. Hæmorrhage seldom occurs before the separation of the sloughs, but there is always danger of its happening during that process. If it occur, pressure or the actual cautery will be found the best means to arrest it; and, if these fail,

ligature of the artery higher up the limb, or amputation when practicable, might be required.

Parts that are quite dead, but that do not readily separate, such as tendons, ligaments, and bones, may be cut through, and thus many weeks or months saved in their separation. It may occasionally be necessary in doing this to encroach on the living tissues; this should be done as carefully and as sparingly as possible, for reasons already stated.

The line of separation should be dressed with some mild antiseptic lotion or ointment, in order to keep the surface clean and to prevent the absorption of septic discharges. If sloughs do not readily separate, the balsam of Peru, either pure or diluted with yolk of egg, or very dilute nitric acid and opiate lotions are useful applications. After the separation of the sloughs, the ulcerated surface must be treated on general principles.

Having thus briefly considered the treatment of gangrene in general, it remains to indicate certain special points in the treatment of the most important varieties. The question of **Amputation** in cases of gangrene of the limbs is of great importance to the practical Surgeon, and requires our attention.

In the treatment of *local gangrene*, such as that following severe injury, it is a general rule to amputate before the occurrence of the line of demarcation. There are, however, two exceptions to this rule; viz., gangrene from frost-bite, and that from severe burns. In these injuries it is better to wait for the formation of the line of separation, and then to fashion the stump just above it as the circumstances of the case may require. The rule of early amputation also applies to cases of gangrene resulting from wound or ligature of an artery.

The question of amputation in those forms of *gangrene consequent on specific infective processes*, as phlegmonous erysipelas, spreading traumatic gangrene, or hospital gangrene, will be fully considered with those diseases. Such operations often give the only chance of life, but their results are on the whole very unfavourable, the patient usually sinking from a recurrence of the disease in the stump, or from the constitutional disturbance that had previously set in.

In *spontaneous gangrene* from disease of the arteries, it was until recently a golden rule in Surgery never to amputate until the line of separation had formed, and not indeed until the ulceration had extended so deeply into the tissues that there was no chance of the gangrene overleaping the barrier. This rule, which was founded on the fact that it may be impossible in such cases to determine to what height in the limb the gangrene will spread, was justified by the excellent results often obtained. In following this plan of treatment means must be taken to maintain the patient's strength by the administration of tonics, nourishing food, &c., during the process of separation. As soon as all the soft parts, except the ligaments, have been ulcerated through, the mortified part should be separated by cutting through the remaining osseous, ligamentous, or tendinous structures, and then means should be taken to fashion the stump that has been formed by nature. In some cases this will be sufficiently regular to serve every useful purpose after it has cicatrized. In most instances, however, the stump is more irregular and unsightly (of which Fig. 339 is a good illustration): and the bones protrude to such an extent that it is necessary, in order to give the patient a useful limb, to amputate through the face of the stump, or

higher up. All this must be left to the discretion of the Surgeon; but no procedures of this kind should be undertaken until the patient's strength has been restored sufficiently to bear the operation.

The tedious process of separation of the gangrenous part is however by no means devoid of serious risk to the patient, and thus it has come about that attempts have been made to hasten the cure of such cases by amputation through a part of the limb in which the circulation appears to be still active. This method of treatment will be considered in connexion with senile gangrene, in which it has been followed by excellent results. In a remarkable

Fig. 339.—Spontaneous Amputation in Gangrene of Right Foot and Left Leg from Embolism.

case recorded by Pearce Gould of symmetrical gangrene of both feet from obliterative disease of the arteries and veins amputation was successfully performed through the knee-joints before a line of demarcation had formed.

In *gangrene from embolism*, the amputation may as a rule be performed at an early period, provided the patient's general condition is such as to justify the operation, but it should not be undertaken until the supply of blood to the tissues immediately above the gangrenous parts is fully restored, and a distinct line of demarcation has formed, close to which the incisions may safely be carried.

In *senile gangrene* the constitutional treatment is important, and although depletory measures are never admissible, we must guard against over-stimulation of the patient. Senile gangrene commonly occurs in individuals belonging to the wealthier classes of society, who have lived high, taken insufficient exercise, and consequently induced an irritable, plethoric, but enfeebled state of system. In many cases the patients are of a gouty habit, and occasionally the inflammation that precedes the development of the gangrene appears to be of this nature. In this condition stimulants and the more powerful tonics are not well borne; they accelerate the pulse and interfere with digestion. As Brodie observes, it is of great importance in this disease to attend to the state of the digestive organs, in order that nutrition may go on, and that blood of a proper quality may be made. In order to accomplish this, a light nourishing diet, partly animal and partly vegetable, should be given, and a moderate quantity of wine, beer, or brandy allowed. The bowels must be relieved from time to time by a saline aperient, a rhubarb draught, or simple aperient pill. Mercury depresses the patient, and hence it should not be used as an aperient in any form in this disease, unless the state of the liver imperatively demand it. If the digestion become impaired, a stomachic, as the infusion of cascarilla or the compound infusion of gentian with a little ammonia, may be given.

The administration of opium in these cases, as originally recommended by Pott, has received the sanction of almost every practical Surgeon. Brodie's opinion on this point is especially valuable; he says, "If I am not greatly mistaken, the result of a particular case will very much depend on this—whether opium does or does not agree with the patient." From two to four grains of opium may be administered in divided doses in the course of twenty-four hours; the quantity being increased as the system becomes accustomed to its effects. If, however, it disturb the stomach and occasion headache, notwithstanding the use of aperients, as will often happen when there is febrile disturbance in persons of a full habit of body, it must be discontinued. The pain in the foot, which is often very severe during the progress of the disease, usually ceases when the mortification is complete; before this, it is but little influenced by sedatives, whether constitutionally or locally applied.

It may be stated generally that in those cases in which there is much fever, in which the tongue is loaded, the pulse quick, and the skin hot, in which the spread of the grangrene is preceded by a red angry blush, with much pain and heat, moderate diet and mild tonics will be most useful; whilst on the other hand, when it is simply a shrivelling of the toes and feet, without any preceding local inflammation, or febrile disturbance, a decided tonic or stimulating plan will succeed best.

If the gangrene be limited to one or more of the toes the local treatment should consist in maintaining the temperature of the part and endeavouring to prevent putrefaction of the dead tissues. This is best done by surrounding the part in a sheet of antiseptic wool, which need not be changed more than once or twice a week. Should the gangrene be of the moist variety the dead part may be painted with carbolic acid and glycerine (1 in 5), or some such powerful antiseptic, before being covered with wool. When the soft parts have been separated, the bone may be cut through and the sore dressed with some antiseptic lotion or stimulating ointment.

If however the gangrene be more extensive and involve the foot much danger inevitably attends the separation of the dead parts. To avoid this amputation may in suitable cases be performed without waiting for the formation of a line of demarcation. This practice has been successfully adopted by Garlike, James of Exeter, Jonathan Hutchinson, and others, and certainly is a justifiable proceeding in well selected cases in which the health is otherwise good, the constitution tolerably sound, and the gangrene so extensive as to make it very doubtful if the patient would survive the process of natural separation of the dead parts. In gangrene of the foot the amputation should be done immediately above the knee, as if performed lower down there would be great danger of sloughing of the flaps. The circular method should always be adopted, as it makes the smallest wound, and avoids the danger of sloughing attending a flap operation. A convenient mode of amputation in such cases has been described on p. 138. The operation must be performed with strict antiseptic precautions, and some form of lasting antiseptic dressing will be found most convenient in the after-treatment. Amputation should not be undertaken merely to give a patient a "last chance," when he is already dying of exhaustion or septic poisoning, as when performed under these circumstances it has usually been fatal within twenty-four hours.

In *diabetic gangrene* the administration of opium or codeia and the exclusion of starchy and saccharine matter from the diet may in some cases arrest the

gangrenous process. König, however, showed, and the statement has been confirmed by others, that the gangrenous inflammation may cause an increase in the amount of sugar and intensify the other symptoms, and that under these circumstances anti-diabetic treatment is likely to fail.

Until recent years the question of amputation for diabetic gangrene did not present itself. Experience has, however, shewn that extensive wounds will often heal quite satisfactorily in patients suffering from diabetes if strict asepsis can be maintained. This has been especially insisted upon by König, and amputation for diabetic gangrene has also been advocated by Roser and Küster, and recently in this country by Godlee and Spencer. It has already been pointed out that arterial disease is doubtless a most important factor in the production of the gangrene of diabetes, and indeed in cases which appear to be of this variety the same rules of local treatment may guide the Surgeon as in senile gangrene. If high amputation be undertaken no pains must be spared to keep the wound aseptic. In the more chronic and painless forms of this affection, which are probably, in part at least, dependent on changes in the nerves, Godlee suggests that the case may more safely be left for the chance of separation by natural means. The high amputation is under these circumstances hardly likely to be called for; and if removal of the limb be practised, it may be done a short distance above the gangrenous part.

In the treatment of *Raynaud's disease* gangrene must if possible be prevented by improving the nutrition of the limb, for which purpose shampooing and galvanism have proved of service. Barlow recommends that the extremity of the affected limb be immersed in a basin of salt water, whilst one pole of a constant-current battery is placed on the upper part of the limb, and the other in the basin. The strength of the current should be such as the patient can comfortably bear, and it should be made and broken frequently. If gangrene occurs and is limited to the fingers or toes Raynaud strongly recommends that the dead part should be allowed to separate by natural means. It is only in those rare cases in which the process is more extensive that the advisability of amputation will have to be considered on the same grounds as in other forms of spontaneous gangrene.

BED-SORES.

When a part of the body is compressed too severely, or for too long a time, even in a healthy person, it loses its vitality, and a limited slough results; this separates, and an ulcer is left, which cicatrizes in the usual way. But in certain deranged states of the health, more especially when the blood is vitiated, and the constitutional powers lowered, as during fever, or when the heart is diseased and weakened, more particularly if the patient be old and debilitated, or if innervation be acutely affected, and he be paralysed, the skin covering those points of the body that are necessarily pressed upon in the recumbent position, such as the sacrum, the trochanters, the elbows, shoulders, and heels, becomes congested and inflamed, assuming a dull reddish-brown colour, and speedily becomes excoriated, often without any pain being felt by the patient. One great cause of bed-sores is undoubtedly bad nursing. It would not be just to say that a bed-sore is always the result of negligent nursing, but it may truly be said that the chance of the formation of bed-sores, and their severity when formed, will be increased or diminished in the

exact ratio of the negligence or care of the nurse. It is not so much the actual severity of the pressure that occasions a bed-sore, as moderate long-continued pressure applied to a part congested by position in a patient enfeebled by disease. If means be not taken to relieve the part from the injurious compression to which it is subjected, and more especially if it be allowed to become irritated by the contact of fæces or urine, the subcutaneous areolar tissue corresponding to the inflamed patch will be converted, with the skin covering it, into a tough greyish slough, from under which a thin ichorous pus exudes. This slough may extend by a process of undermining of the integuments covering it; and on its separation extensive mischief will be disclosed, the fascia and muscles being exposed, or the bones even laid bare, and soon becoming roughened and carious. In some cases even the inferior aperture of the spinal canal may be laid open, and death result from septic meningitis. In other cases, the patient is worn out by discharge and irritation, or succumbs to pyæmia or septicæmia.

TREATMENT.—This is in a great measure preventive. When a patient is likely to be confined to bed for many weeks, especially by exhausting disease, steps should be taken by proper arrangement of the pillows, and by the use of a water-bed or cushions, to prevent pressure from being injuriously exercised upon any one part. If the patient be unable to move himself his position should be changed by the nurse at regular intervals. At the same time, cleanliness and dryness should be carefully provided for by proper nursing, by the use of a draw-sheet, and by furnishing the bedstead with the necessary arrangements for using the bed-pan, &c. The back should be periodically examined by the Surgeon himself. The skin on the exposed parts may be protected by the application of collodion or soap-plaster spread upon wash-leather or amadou, or isinglass on felt; or, what is better, it may be strengthened by being washed with spirits of wine. In some cases much benefit is derived from frictions of brandy and glycerine in equal parts. If the skin has become reddened it should be painted with a solution of nitrate of silver, of gr. v. to ℥j.

If the skin have become chafed, the removal of pressure is imperative, and the abrasion may be washed over with collodion. If a sore have formed it may be dressed with boric acid ointment, or balsam of Peru, spread upon lint. In some cases the prone couch may occasionally be advantageously substituted for the ordinary bed previously employed. When sloughs have formed, their separation must be facilitated by the use of moist antiseptic dressings, as boric acid lint and lotion, and the ulcers that are left should be treated on ordinary principles, the utmost attention being paid to cleanliness by the use of antiseptic lotions; but no dressing that the Surgeon can apply will cause these ulcers to clean, and still less to heal, unless pressure be removed and the patient's general health improve, when they will speedily cicatrize under the most simple treatment.

BOILS.

A BOIL OR FURUNCLE is a localized inflammation affecting the skin and subcutaneous tissue terminating in the formation of a small conical slough of areolar tissue called the *core*, around which suppuration takes place, the dead tissue being finally separated and discharged by an opening through the skin.

The inflammation starts in connection with a hair, but whether from the follicle itself or from the sebaceous gland is uncertain ; probably it may commence in either situation. It begins as a small red pimple, through the middle of which the hair may often be seen protruding. From this the inflammation extends into the subcutaneous tissue ; it is accompanied by abundant coagulable exudation, so that the inflamed area becomes raised above the surrounding parts, forming a hard circumscribed tumour of a purplish-red colour, conical in form, but flattened at the top. On the summit of this a vesicle forms which bursts, leaving a grey slough exposed, which is gradually loosened by suppuration around it, and discharged usually by a single opening, after which the small cavity heals rapidly. In the early stages there are itching and tenderness, but as the tension and hardness increase the boil becomes extremely painful. Boils are always seated on parts provided with hair, the most common situations being the back of the neck, the shoulders, nates, and hands. They seldom occur singly, one usually following another for some weeks or even months. The nearest lymphatic glands are usually swollen, but very rarely suppurate. In some cases the inflammation subsides without suppuration, and the boil is then said to be *blind.*

Predisposing Causes.—Boils most frequently occur in young people, but are common enough at all ages. They are met with sometimes in very plethoric, and sometimes in enfeebled, constitutions, often following some of the more severe febrile diseases, and attending convalescence from them ; they are not uncommon in diabetic subjects. The boils which often break out during training for athletic contests are supposed to be due to a too exclusively animal diet. Sometimes boils may be traced to exposure to sewer-gas. In other cases, the system appears to have fallen into a cachectic state, often without any evident cause, and this terminates by a critical eruption of boils. A sudden change in the habits of life, as from sedentary to active pursuits, a course of sea-bathing, &c., will also occasion them. They are commonly met with in the spring of the year, but may occur at all seasons, and are occasionally epidemic.

Immediate Causes.—Many years ago Pasteur showed that a micrococcus was always present in the discharge that could be obtained from a boil by puncturing it and squeezing it at an early stage. This organism has since been identified as the staphylococcus pyogenes so commonly found in all acute suppurations. That it can act as a cause of boils has been shown by Garré, who rubbed a gelatine cultivation of the staphylococcus obtained from a case of acute necrosis of bone into his own arm, with the result of producing a closely set crop of boils. Boils are also well known to be common on the hands from the contact of decomposing animal matter in *post-mortem* examinations. Friction seems an important local cause, as they are most common on the neck at the part rubbed by the collar, and are often met with on the nates from rowing.

Treatment.—If any definite constitutional condition can be discovered upon which the boils seem to be dependent it must be attended to. The urine should always be tested for sugar and albumen. The drains of the house in which the patient lives should be examined as the disease may be due to poisoning by sewer-gas. Boils may occur in the most opposite conditions of health, and different modes of treatment are consequently necessary. If the patient be debilitated and cachectic, iron, quinine, and cod-liver oil ; if he be

plethoric, and the system loaded, purgatives, salines, and liquor potassæ will be appropriate. In the one case an abundant nourishing diet, in the other case a spare and simple one, with avoidance of stimulants, will be required. Change of air is often very beneficial. In some cases empirical means are of service. Thus, when the disease is associated with pompholyx, or preceded by painful vesicles, arsenic may be of benefit. In other instances, yeast or charcoal has been advantageously given. Ringer strongly recommends the administration of sulphide of calcium both for preventing the formation of fresh boils and hastening the separation of the slough in those that have already appeared. A tenth of a grain may be given hourly or a third of a grain four times a day.

The *Local Treatment* is simple. When the boil is in its earliest stage, if a hair can be seen projecting through the pimple, it should be pulled out with forceps. The development may in some cases be arrested also by touching it with nitrate of silver, or with a saturated solution of perchloride of mercury. When the boil is evidently forming the red area around it should be painted with equal parts of glycerine and belladonna. This usually relieves the pain and protects the skin from the irritation of the poultices or other applications. Hot, moist applications must then be employed; four layers of wet boric acid lint covered with oiled silk and cotton-wool, or a linseed meal poultice well greased on the surface, forms the best application. Poultices, however, in many cases irritate the surrounding skin, and encourage the formation of a fresh crop of boils. Nothing will be found to give so much relief or to hasten suppuration more than the application of a sponge squeezed out of water, as hot as the patient can bear it, and changed every few minutes. If the patient is confined to the house, he can carry out this treatment himself for several hours during the day. Most commonly a boil may be allowed to break, but the Surgeon may in some cases find it necessary to incise it when it is large, and does not appear disposed to break of itself.

CARBUNCLE.

A Carbuncle is a specific spreading inflammation of the subcutaneous areolar tissue, implicating the skin and terminating in death of the affected tissues, with the formation of a pulpy greyish or ash-coloured slough. Whether it commences in the deep layers of the true skin—possibly in the sebaceous glands, or in the subcutaneous areolar tissue—has not been definitively determined.

Signs.—A carbuncle begins as a flat or very slightly conical inflammatory swelling of the skin, the base of which is hard, and the edges clearly defined: it is of a dusky-red colour and is accompanied from the first by a burning, stinging, heavy, or throbbing pain in the part, out of proportion to the apparent gravity of the disease. The inflamed base steadily enlarges and implicates the subcutaneous tissue more deeply, forming a flat, slightly elevated, hard, circumscribed swelling, gradually becoming doughy as sloughing sets in. As it increases in size, the swelling maintains its flattened circular or oval shape, and the skin covering it assumes a purple or brownish-red tint. Vesicles form on it at several points, which speedily become pustular and burst, exposing openings beneath in the cutis, through which the ash-grey sloughs appear, and from which unhealthy purulent discharge scantily issues. The openings in

the thin undermined skin gradually melt into each other, and the slough slowly separates. In most cases, the whole thickness of the subcutaneous fat is not destroyed; but occasionally when the slough comes away the deep fascia or even the muscles may be exposed.

The size of the swelling varies from one to six inches in diameter; most commonly it is about two inches across. Carbuncles are generally met with on the posterior part of the trunk, more especially about the shoulders and the nape of the neck; being rarely seen anteriorly, or on the extremities. I have, however, had to treat very large carbuncles on the abdomen, and have met with them on the shin, forearm, and forehead. A carbuncle is almost invariably single; but some years ago I had under my care a patient in whom a large carbuncle was followed by the appearance of about a dozen smaller ones scattered over the back, in spite of which he finally recovered.

The **Constitutionl Disturbance** attending this disease is always of the asthenic type; the complexion is often peculiarly sallow or yellow, the pulse feeble, and the tongue loaded; and if the carbuncle be large, or be seated on the head, death may take place, the patient frequently sinking from septicæmia or pyæmia.

Causes.—A carbuncle arises usually without any assignable local exciting cause; but in some cases it is evidently occasioned by the introduction of some poisonous matter into a puncture in the skin or into a hair-follicle. In all cases it is associated with and dependent upon a disordered state of the constitution, and any condition that lowers the powers of the system will predispose to it. Habitually bad and insufficient food, the exhaustion induced by chronic wasting diseases, especially diabetes, or the debility resulting from acute febrile diseases—more particularly typhus—may all occasion it. Carbuncles are more common in men than in women, and in the old than in the young, being very rare under twenty. They occur more frequently in some years than in others. Micrococci are abundantly present in the diseased tissues, but no specific organism definitely related to the disease has been discovered.

Diagnosis.—A carbuncle resembles a *boil* in many points, yet differs in its greater size, in the dusky-red colour of the inflamed integument, in its broad flat form, and in the large quantity of contained slough in proportion to the small amount of purulent discharge in the numerous openings on the surface, as well as in the conditions in which it generally occurs. It differs from a boil also in its tendency to spread. A boil "comes to a head," bursts, and discharges pus and slough; a carbuncle will be discharging and sloughing at one part, whilst it spreads, hard and brawny, at another. A carbuncle is almost invariably single; boils most commonly appear in crops.

The **Prognosis** in carbuncle will depend on its size and situation, and on the state of the patient's constitution, more particularly on that of his kidneys. The most dangerous carbuncles are those that are large, and situated or encroaching on the scalp; in fact, the more this structure is involved the greater the danger. If the constitution be good, even these may be recovered from; but if the kidneys be unsound, or if there be saccharine diabetes, the progress of the disease cannot readily be checked, and the patient will usually sink.

Treatment.—The **Constitutional Treatment of carbuncle** must be guided by the constitutional state that accompanies the local disease. If the

carbuncle occur in a debilitated person, the tincture of the perchloride of iron in small and frequent doses, with a moderate allowance of alcoholic stimulants and a good diet, will be necessary. If the patient be diabetic, opium must be freely administered, unless chronic bronchitis or albumen in the urine should contra-indicate it. If the carbuncle occur in a person of advanced years addicted to high living, and possibly not temperate in habits, the ordinary treatment of inflammation of a sloughing character must be adopted. The bowels having been freely cleared out, ammonia and bark, or quinine, must be given. Alcoholic stimulants may be more freely administered. But they must be administered medicinally in measured quantities, and at intervals of longer or shorter duration according to the need of the patient as determined by his pulse and temperature. Port-wine used to be the favourite remedy. It is considered less necessary at the present day than it was a generation or two back, and brandy or whiskey with milk or eggs is commonly substituted for it. But whatever stimulant be given, too much care cannot be taken in regulating its doses and times of administration, which must not be left to the discretion of the non-medical attendant. In addition to stimulants, good and abundant nourishment should be given; meat, if the patient can digest it; if not, soups, such as strong beef-tea, essence of meat, or turtle-soup.

Local Treatment.—In the very early stage the progress of a carbuncle may be arrested by destroying it with a pointed stick of potassa cum calce. If the carbuncle have attained a somewhat larger size, though still small, it may be covered with a piece of soap-plaster spread on leather, having a hole cut in the centre, through which the pus and sloughy matters may be discharged. When the carbuncle is of still larger size the question will arise whether it should be incised or not. Some Surgeons uniformly adopt incisions; others, with equal constancy, reject them. I think that the exclusive adoption of either method is erroneous, and that the most successful treatment consists in allowing the question of early incision to be determined by the amount of tension existing in and around the carbuncle. Should the parts be soft, relaxed, and comparatively painless, an incision is not necessary; but, on the other hand if the tension be considerable, the pain great, and the constitutional disturbance dependent on both proportionately intense, nothing gives such immediate relief, local and constitutional, as early and free incision. The crucial incision which has been largely employed is sometimes convenient, but often presents no advantages over a single straight one. The bleeding may be free, and as the patient is seldom in a state to lose blood it must at once be restrained by dry cotton-wool and pressure. Hueter advises that if the patient is strong enough to stand the necessary loss of blood, and if the carbuncle be not too large, the whole slough should be scraped or dissected away at the time the incision is made. The cavity thus left should be well scrubbed out with some powerful antiseptic lotion and dressed antiseptically. In this way extension is arrested and the fever due to the presence of the slough immediately subdued.

Should incision of the carbuncle not have been performed early, it may become necessary at a later period, in order to prevent the confinement of the pus and sloughs. Pyæmia is so frequent a cause of death in bad cases of carbuncle, that it becomes very important to prevent putrefaction in the sloughs, if possible. If an incision be made before the skin has given way,

it should be done with antiseptic precautions. The surrounding skin should be washed with carbolic lotion, and as soon as the incision has been made an antiseptic dressing should be applied. At subsequent dressings the surface must be irrigated with some antiseptic lotion. Iodoform sprinkled on the sore is often most useful. Poultices should be avoided as tending to encourage putrefaction. If warmth and moisture are required, a thick layer of boric acid lint wetted with a concentrated solution of boric acid or salicylic wool moistened with warm water, will be found the most convenient application; or if these be not at hand, the carbuncle may be covered with some lint soaked in carbolic oil (1 in 10), or terebene and oil, or some other antiseptic dressing, over which a fomentation may be applied. As the sloughs loosen, they should be separated; and the granulating surface which is left, and which will usually be found to be sluggish in healing, should be dressed with some of the more stimulating ointments, such as those of elemi, resin, or balsam of Peru.

FACIAL CARBUNCLE.—Under this name has been described by Ludlow, T. Smith and others, a somewhat rare form of gangrenous inflammation of the face. It appears first as a pustule or vesicle on the lip—according to Smith, most commonly on the upper lip. It is surrounded by a red blush, and the tissues beneath are swollen and œdematous. The swelling spreads rapidly, often involving a great part of one side of the face; in a few days its edge is less clearly defined, and the swollen tissues are more œdematous and less brawny than in a common carbuncle. Suppuration takes place after two or three days, in patches scattered through the swollen tissues. The skin in the central part becomes dusky in colour, and the subcutaneous tissue breaks down into soft shreddy sloughs soaked in pus. The constitutional symptoms are of the gravest kind; there is considerable elevation of temperature at first, with dry tongue and great prostration. Should the patient survive to the period of sloughing and suppuration, death may take place from pyæmia or septicæmia. Embolic pyæmia is very common following septic thrombosis of the large veins on the side of the face.

In rare cases the disease may commence about the nose and extend to the eyelids. It may then be fatal by septic thrombosis extending backwards by the ophthalmic vein to the cavernous sinus. In this condition there is great swelling of the eyelids, and pus may form deeply in the orbit. It is speedily fatal from meningitis or pyæmia. The exact relation of this affection to true carbuncle is doubtful. T. Smith believes it to differ only in the greater acuteness and intensity of the process, but I do not think it can be considered a carbuncular inflammation. Its whole course and the appearance of the inflamed part rather indicate its alliance to phlegmonous erysipelas. Death ensues usually in from forty-eight hours to five or six days after invasion. It is a very grave, but not a hopeless affection.

Diagnosis.—The disease somewhat resembles malignant pustule, with which it has often been confounded. The black slough surrounded by vesicles which is so characteristic of the latter disease, is, however, wanting in facial carbuncle. Moreover, in malignant pustule the slough is dry, while in facial carbuncle it is soaked in pus.

Treatment.—Abundance of liquid nourishment and stimulants are required, and Paget recommends the administration of quinine in large doses. Locally, incisions seem to have been of but little use; the application of hot

carbuncle occur in a debilitated person, the tincture of the perchloride of iron in small and frequent doses, with a moderate allowance of alcoholic stimulants and a good diet, will be necessary. If the patient be diabetic, opium must be freely administered, unless chronic bronchitis or albumen in the urine should contra-indicate it. If the carbuncle occur in a person of advanced years addicted to high living, and possibly not temperate in habits, the ordinary treatment of inflammation of a sloughing character must be adopted. The bowels having been freely cleared out, ammonia and bark, or quinine, must be given. Alcoholic stimulants may be more freely administered. But they must be administered medicinally in measured quantities, and at intervals of longer or shorter duration according to the need of the patient as determined by his pulse and temperature. Port-wine used to be the favourite remedy. It is considered less necessary at the present day than it was a generation or two back, and brandy or whiskey with milk or eggs is commonly substituted for it. But whatever stimulant be given, too much care cannot be taken in regulating its doses and times of administration, which must not be left to the discretion of the non-medical attendant. In addition to stimulants, good and abundant nourishment should be given; meat, if the patient can digest it; if not, soups, such as strong beef-tea, essence of meat, or turtle-soup.

Local Treatment.—In the very early stage the progress of a carbuncle may be arrested by destroying it with a pointed stick of potassa cum calce. If the carbuncle have attained a somewhat larger size, though still small, it may be covered with a piece of soap-plaster spread on leather, having a hole cut in the centre, through which the pus and sloughy matters may be discharged. When the carbuncle is of still larger size the question will arise whether it should be incised or not. Some Surgeons uniformly adopt incisions; others, with equal constancy, reject them. I think that the exclusive adoption of either method is erroneous, and that the most successful treatment consists in allowing the question of early incision to be determined by the amount of tension existing in and around the carbuncle. Should the parts be soft, relaxed, and comparatively painless, an incision is not necessary; but, on the other hand if the tension be considerable, the pain great, and the constitutional disturbance dependent on both proportionately intense, nothing gives such immediate relief, local and constitutional, as early and free incision. The crucial incision which has been largely employed is sometimes convenient, but often presents no advantages over a single straight one. The bleeding may be free, and as the patient is seldom in a state to lose blood it must at once be restrained by dry cotton-wool and pressure. Hueter advises that if the patient is strong enough to stand the necessary loss of blood, and if the carbuncle be not too large, the whole slough should be scraped or dissected away at the time the incision is made. The cavity thus left should be well scrubbed out with some powerful antiseptic lotion and dressed antiseptically. In this way extension is arrested and the fever due to the presence of the slough immediately subdued.

Should incision of the carbuncle not have been performed early, it may become necessary at a later period, in order to prevent the confinement of the pus and sloughs. Pyæmia is so frequent a cause of death in bad cases of carbuncle, that it becomes very important to prevent putrefaction in the sloughs, if possible. If an incision be made before the skin has given way,

it should be done with antiseptic precautions. The surrounding skin should be washed with carbolic lotion, and as soon as the incision has been made an antiseptic dressing should be applied. At subsequent dressings the surface must be irrigated with some antiseptic lotion. Iodoform sprinkled on the sore is often most useful. Poultices should be avoided as tending to encourage putrefaction. If warmth and moisture are required, a thick layer of boric acid lint wetted with a concentrated solution of boric acid or salicylic wool moistened with warm water, will be found the most convenient application; or if these be not at hand, the carbuncle may be covered with some lint soaked in carbolic oil (1 in 10), or terebene and oil, or some other antiseptic dressing, over which a fomentation may be applied. As the sloughs loosen, they should be separated; and the granulating surface which is left, and which will usually be found to be sluggish in healing, should be dressed with some of the more stimulating ointments, such as those of elemi, resin, or balsam of Peru.

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fomentations, followed by antiseptic dressings when sloughing has taken place, is all that can be done in most cases.

CANCRUM ORIS, OR NOMA.

Cancrum oris is a rapidly spreading gangrenous inflammation attacking the inside of the cheek, most frequently between the second and sixth years of life. It is met with usually in ill-fed, sickly children who have been living under bad hygienic conditions. It commonly occurs during convalescence from some acute specific fever, most frequently measles; or after the incautious administration of mercury during a weak state of the system.

Symptoms.—One of the cheeks becomes red, swollen, brawny, tense, and shining, being excessively hard. It is often difficult to open the mouth; but if the Surgeon can gain a view of its inside, he will see a deep and excavated foul ulcer opposite to the centre of the external swelling, covered with a brown pulpy slough. The gums are turgid, dark and ulcerated; the saliva is mixed with putrescent matters. By the second day a dark purple spot appears in the middle of the red external swelling over which the epithelium separates and the skin quickly becomes gangrenous. The sloughing extends rapidly, until by the third or fourth day a large gangrenous cavity is formed, opening externally through the cheek and internally laying bare the alveolar borders of the jaw. The child suffers little, and, as the disease advances, it commonly becomes drowsy, and at last dies comatose, usually within a week. This affection is most fatal. Rilliet and Barthez state that not more than one case in twenty recovers. Should recovery take place, a large portion of the cheek may be lost, opening the mouth half way back to the ear, or a dense cicatricial band may form between the jaws, making it impossible to open the mouth.

Pathology.—The exact cause of the ulceration is still uncertain. In the ulcerative stomatitis of calves, which in many respects closely resembles cancrum oris, Lingard and Batt have found the line of junction of the necrotic and healthy tissues occupied by a "mass of bacilli having the appearance of a dense phalanx advancing upon the healthy tissues." These were cultivated out of the body, and found capable of causing a spreading necrosis when inoculated on other animals. In one case of cancrum oris which he had the opportunity of examining, Lingard found similar organisms with the same arrangement.

Treatment.—The child must be put under chloroform, and the sloughing mass deeply cauterized. The sloughs should be scraped or scrubbed away before the caustic is applied. Nitric acid is usually recommended in these cases. The actual cautery may also be used, especially when the cheek is already perforated. If the slough appears on the surface externally, it may be cut away before applying the caustic. After cauterization the mouth should be syringed out with diluted Condy's fluid, and the ulcerating surface dusted with iodoform. The strength must be supported with beef-tea, wine, and ammonia. If recovery take place, some plastic operation may be necessary at a later period, in order either to close the gap in the cheek or to enable the child to open its mouth.

NOMA OF THE VULVA—GANGRENOUS VULVITIS.

Gangrenous Inflammation of the Vulva of a character much resembling cancrum oris, and occurring under similar conditions, is occasionally met with in unhealthy, ill-fed female children, and is not uncommonly fatal. It usually attacks the surface of one labium, but soon extends to the other by contact. The parts round are swollen and inflamed, and in the centre is an ash-grey slough, which rapidly extends. The **Treatment** consists in wiping or scraping away the slough and applying fuming nitric acid. After this the child should be kept for some hours every day in a bath of warm boric acid lotion. When in bed, a piece of lint soaked in a solution of boric acid in glycerine and water should be placed between the labia.

CHAPTER XXXI.

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In a true infective process the virus infects the living tissues, increasing in quantity amongst them, and gives rise to unhealthy processes in them. These may be local, the accompanying constitutional disturbance being merely the result of the absorption of the chemical products resulting from the growth of the organisms; or general, when the virus enters the blood-stream and multiplies in it. The former is called a *local*, and the latter a *general infective process*.

In simple septic processes the fungi which are supposed to cause them are said to be non-pathogenic or non-parasitic; in infective processes they are spoken of as pathogenic or parasitic. The term "mycosis" is often used to signify the infection of the living tissues by fungoid organisms.

Although these septic and infective processes are distinct from each other they are nearly related; infective processes very rarely starting from wounds, unless the discharges are in a septic condition. This fact has been explained by supposing that non-pathogenic organisms may develop pathogenic pro-

been already described in Chapter XI.; tetanus will be considered in a subsequent Chapter.

It is impossible here to discuss fully the evidence for and against the micro-parasitic origin of these diseases. It is essential to bear in mind the four postulates which, according to Koch, must be fulfilled, before the causal relation of a micro-organism to any given disease can be taken as proved. First, the organism must be constantly present in cases of the disease; secondly, the organism must be capable of cultivation outside the body; thirdly, the disease must be capable of production by inoculation with the pure cultivation; and fourthly, the same organism must be capable of demonstration in the disease thus produced. Anthrax and cutaneous erysipelas may be quoted as instances in which these necessary conditions have been fulfilled, and, judging by analogy, the probability is great that in allied diseases the same proof will eventually be forthcoming. Further, the course of such diseases, the modifications produced by altered conditions in the body and in its surroundings, and lastly, the modes of prevention are all in keeping with the hypothesis of a living virus.

The chief arguments urged against it are the following. In the first place, it has been urged that many processes, dissimilar in every respect, are found to be associated with the presence of organisms apparently perfectly similar. Thus micrococci are found in a simple acute abscess, in erysipelas and in pyæmia; but with bodies of such extreme minuteness differences may readily exist which it is beyond our power to recognize. Cohn, while referring to this question, called attention to the external similarity of the sweet and bitter almond, which yet differ from each other so widely in their chemical properties. A much more important objection, which is pointed out by Koch himself, is that in many cases in the human subject the number of microscopic organisms found has been singularly small, so small in fact as to make it difficult to understand how they could be the cause of such grave disease. Lastly, it has been maintained that the microscopic organisms are merely an accidental accompaniment of the process and not the cause, or that at most they serve merely as carriers of the virus and are not the producers of it. It is difficult to refute this assertion with the means at present at our command. When, however, as in the case of erysipelas, the organism may be cultivated for twenty generations out of the body in an artificial medium, and finally, on being inoculated on another individual will produce a genuine attack of the disease, it seems difficult to regard it as other than an essential factor in the production of the specific inflammation.

It must be acknowledged therefore, that, although it is highly probable that all the diseases in this group arise directly from the action of micro-organisms, the evidence is not as yet sufficient to furnish in every case demonstrative proof of the truth of this theory.

Supposing, however, that the fungoid theory of infective processes in wounds were proved beyond a doubt, this would in no way disprove the facts previously known as to the influence of bad hygienic conditions in the development of these diseases. The experience of generations of Surgeons has taught us that, although inflammation and suppuration with febrile disturbance result from contact with the raw surfaces of wounds of such simple septic products as must form in all dead tissues or putrescible animal fluids exposed to the ordinary air of a dwelling-house, the graver infective processes are of

extreme rarity in cases treated in pure air and in the isolation of a private house. On the other hand, it has been established incontestably that if the cubic capacity of a ward be taken, and the rate of ventilation through it determined, a Surgeon may with certainty foretell how many suppurating wounds it will require, in the absence of antiseptic treatment, to generate infective disease in it.

Thus, although in the prevention of these diseases the use of antiseptics must take the first place as attacking the evil at its source, a strict attention to the laws of hygiene as regards cubic space, ventilation, and general cleanliness, is also necessary to exclude those accessory conditions that favour its development. By these means combined all this group of diseases can be prevented; their occurrence is the result in almost all cases of some definite error in the treatment of the wound, or of some infringement of sanitary rules. They are not accidental; they are preventable and ought to be prevented. Should a case arise, our knowledge of the nature of the diseases shows clearly how they may be carried from one individual to another, and efficient means to prevent their spread should at once be adopted. The whole subject of the relation of these diseases to general hygienic conditions has already been discussed (pp. 7 *et seq.*), and need not be further considered here.

The view is steadily gaining ground that the local and constitutional symptoms produced in septic and infective processes are the result of the action of chemical products developed during the growth of the micro-organisms. In the investigation of the nature of these chemical products much valuable work has recently been done and is still in progress. The most important fact, which may be taken as definitively established, is that in certain instances, the injection into the body of an animal of a culture of a pathogenic organism, from which the organism itself has been separated by filtration or destroyed by the action of heat, is still followed by the typical symptoms of the disease. This was first demonstrated by Pasteur in 1880, in connexion with chicken cholera; the symptoms of the disease followed the injection of the sterilized products of the bacillus.

In the consideration of Tetanus in the next chapter it will be seen that the characteristic symptoms of the disease can be produced by the injection of the "*toxines*" obtained from a pure cultivation of the tetanus bacillus. It may further be mentioned that paralysis has been produced in animals by the chemical products of the bacillus of diphtheria; coma, swelling of the spleen, etc., by those of the bacillus anthracis; and fatal septic intoxication by a definite chemical body obtained from putrefying blood.

The chemical products themselves belong to two chief classes: first, basic substances, which seem to be closely allied to alkaloids in their chemical composition; and secondly, toxic albumins, especially albumoses.

The relation of these chemical substances elaborated by the growth of pathogenic micro-organisms to the production of acquired immunity is one of great interest, but can only very briefly be referred to here. Pasteur supposed that immunity conferred by a previous attack of an infective disease resulted from the exhaustion of some nutritive material necessary for the growth of the micro-organism. Chauveau, on the other hand, held that it resulted from the retention in the blood of certain products produced by the organism and inimical to its own growth.

At the present day two chief views are held on this important subject.

According to Metchnikoff and his followers immunity is the result of certain changes imposed upon the living cells which act as phagocytes. In the Chapter on Inflammation (pp. 160 *et seq.*), it has been seen that the behaviour of leucocytes towards invading micro-organisms is possibly determined by the chemical products of the latter. If these are positively chemiotactic the leucocytes are attracted and the organisms destroyed by them; if on the other hand the chemical substances are negatively chemiotactic, the leucocytes are repelled and the micro-organisms gain the day. The same chemical product which in a susceptible animal acts negatively is supposed in the immune animal to act in a positive manner, and thus death of the invading organisms results.

On the other hand, Buchner and others believe that a bacteria-killing substance exists in the blood of immune animals, and that phagocytes play only a secondary part in the process, being attracted to the organisms which are already dead. Hankin has suggested that certain substances, which he speaks of as "protective proteids," are the essential agents, and are persistently in process of formation in the body of the immune animal.

LOCAL INFECTIVE PROCESSES IN WOUNDS.

WOUND-DIPHTHERIA.

This name has been applied by French and German writers to an unhealthy condition assumed by granulating wounds, in which they become covered by an opaque, white, or yellowish-white membranous layer closely resembling the false membrane of diphtheria. By English Surgeons it has more commonly been described as a mild form of phagedænic ulceration. It arises invariably in connection with decomposing discharges, and is not uncommon in wounds over which urine is flowing. The granulating sore which may have been in a healthy condition up to the time of the attack, becomes dark in colour, and here and there small hæmorrhages may be noticed amongst the granulations. The healthy discharge of pus ceases, and is replaced by a very slight serous exudation. Then an opaque white patch appears and soon spreads over the surface. The surrounding skin becomes reddened and slightly swollen, the edges are raised and sharply cut, and the sore may slowly spread and deepen. The opaque white layer on the surface is difficult to remove, but if a small piece be peeled off and examined microscopically it will be found to be composed of the superficial layers of the granulation cells which have perished and become finely granular, mixed with a coagulated exudation. Throughout the whole layer are abundant micrococci, singly, in chains, and in colonies. There is usually some slight febrile disturbance, and the nearest lymphatic glands are swollen.

Causes.—This unhealthy process is always the consequence of local neglect of cleanliness and general imperfection of hygienic arrangements. It may affect several wounds in a ward, but its contagiousness is not very clearly marked, and it frequently occurs in isolated cases. It has no relation to diphtheria. It is true that a similar unhealthy condition has been observed in wounds when the patient has been attacked by genuine diphtheria; but the constitutional condition is then entirely different. Diphtheritic inflammation in the throat does not lead to the progressive destruction of tissue

observed in the so-called wound-diphtheria. Wound-diphtheria is much more nearly allied to hospital gangrene; in fact, the term is extended by many writers on the Continent to that process, the affection here described being regarded as the mildest form of the same disease. It is well, however, to separate the process above described from genuine hospital gangrene, on account of its less evident contagiousness and its comparatively harmless character.

Treatment.—This is very simple. It is only necessary to apply some strong antiseptic lotion, such as chloride of zinc (gr. 40 to ℥j), carbolic acid (1 in 20), or the surface may be rubbed over with solid nitrate of silver or sulphate of copper. When a wound assumes this condition the hygienic surroundings of the patient should be carefully investigated, and any faults of ventilation, cleanliness or drainage corrected. In the mildest cases dusting the surface with iodoform may be sufficient to arrest the unhealthy process.

HOSPITAL GANGRENE.

This affection is also known by the names of contagious or pulpy gangrene, or sloughing phagedæna, and by some French and German writers the term wound-diphtheria is extended to it. It is characterized by a rapidly destructive and spreading infective inflammation, the affected wound becoming covered by an adherent slough as the process extends. It attacks open sores and wounds. It is rarely met with in its fullest extent, except in military practice; the accumulation of a large number of wounded persons with foul suppurating sores under one roof, and the want of proper cleanliness and attention during an active campaign, disposing to it.

Local Signs.—When hospital gangrene invades a wound or open sore that has hitherto been perfectly healthy, grey soft points of slough appear upon it, which rapidly spread, until the whole of the surface is affected. At the same time the sore increases rapidly in superficial extent, and commonly in depth; the surrounding integument becomes œdematous, swollen, and of a livid red colour; the edges of the ulcer are everted, sharp-cut, and assume a circular outline; and its surface is covered with a thick pulpy greyish-green tenacious mass, which is firmly adherent. There is usually some dirty yellowish-green or brownish discharge, and occasionally some bleeding; the pain is of a severe burning character; and the fœtor from the surface is great. The ravages of this disease, when fully developed, are very extensive. The soft parts, such as the muscles, areolar tissue, and vessels are transformed into a grey pulpy mass, and the bones are denuded and necrosed. The larger blood-vessels resist the progress of the disease longer than any other parts, but may at last be exposed, pulsating at the bottom of the deep and foul chasm. There is, however, little risk of hæmorrhage in the early stages; but, when the sloughs are separating, an artery may give way, and bleeding to a dangerous or fatal extent ensue. Hennen states that there is most danger of this about the eleventh day. When the sloughs are thrown off, in the form of reddish-brown or greyish-green, viscid, and pulpy masses, a very sensitive granulating surface is left, having a great tendency to bleed, and to be again invaded by the gangrenous process.

Blackadder has described a form of this affection, in which a vesicle containing a bloody ichor forms, with a hot stinging pain; this breaks, leaving a

circular ulcer of about the size of a split pea. The ulcer once formed, rapidly extends by sharp-cut edges into the surrounding integument.

CONSTITUTIONAL SYMPTOMS.—In the early stage there may be active febrile disturbance, with high temperature and quick pulse. But these symptoms soon subside into those of prostration. In the majority of cases the constitutional symptoms follow the local invasion of the wound. This was certainly so on the two occasions in which in former years I had an opportunity of observing outbreaks of the disease in University College Hospital; and the same has been noted by Delpech, Blackadder and others.

CAUSES.—All wounds and sores are liable to be attacked in this way, but the disease most frequently affects those that are of recent origin. Hutchinson believes that it is specially prone to originate in syphilitic subjects. The experience of many wars has led incontestably to the conclusion that hospital gangrene will certainly be developed amongst the wounded if they are crowded in too great numbers under one roof, however large may be the building; whilst, amongst the wounded who are treated in the open, or in "hut hospitals"—mere temporary sheds—it is all but unknown. In many German hospitals in which it was formerly of very frequent occurrence, it has been entirely excluded by the adoption of antiseptic methods of treating wounds, all other conditions remaining unchanged. It is evident, therefore, that the disease is primarily due to two causes, the overcrowding of patients in a ward and the putrefaction of the discharges from their wounds. The last outbreak that occurred at University College Hospital, more than twenty-five years ago, was evidently due to these causes. In one of my wards, which was intended to contain 15 or 16 patients only, owing to accidental and unavoidable circumstances, 21 patients were admitted, and slept for one night, many of them having suppurating wounds. The result was an outbreak of hospital gangrene, which spread through the institution, and was most serious and persistent. But though it commonly has its origin in this way, especially in the crowding of military hospitals after a hard-fought action, it is met with out of hospitals. Well-marked cases of this affection, some of a very severe character, have at times occurred amongst the out-patients of University College Hospital. In these cases, as in many others, it is probable that the disease was occasioned by the neglect of hygienic conditions, in the close and ill-ventilated houses of the poor, aided possibly by some atmospheric or epidemic influence; erysipelas and phlebitis being also very prevalent at the time. This had been observed during the first occurrence of the disease at our Hospital, in 1841; and it is impossible not to recognize a similarity of cause in these different affections. Hospital gangrene is highly contagious, and when once it has broken out it will readily spread from patient to patient by contact with nurses' or Surgeons' fingers, instruments, dressings, and above all if the pernicious custom of using sponges in cleaning sores be adopted. It is impossible to be too careful in these respects. The disease may also be carried by the air, and may thus be said to be "infectious."

Pathological Anatomy.—The slough is composed of the tissues of the part infiltrated with inflammatory products, the fluids having undergone coagulation. The individual cells are not recognizable, the whole presenting a finely granular appearance. When stained and properly prepared, innumerable micrococci are seen amongst the granules; they are in colonies or chains, or single. The perishing tissues immediately beneath the slough are

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In a true infective process the virus infects the living tissues, increasing in quantity amongst them, and gives rise to unhealthy processes in them. These may be local, the accompanying constitutional disturbance being merely the result of the absorption of the chemical products resulting from the growth of the organisms; or general, when the virus enters the blood-stream and multiplies in it. The former is called a *local*, and the latter a *general infective process.*

In simple septic processes the fungi which are supposed to cause them are said to be non-pathogenic or non-parasitic; in infective processes they are spoken of as pathogenic or parasitic. The term "mycosis" is often used to signify the infection of the living tissues by fungoid organisms.

Although these septic and infective processes are distinct from each other they are nearly related; infective processes very rarely starting from wounds, unless the discharges are in a septic condition. This fact has been explained by supposing that non-pathogenic organisms may develop pathogenic pro-

perties when growing in a suitable medium, such as the discharges of an unhealthy wound are assumed to be. Evidence is, however, wanting to prove this. The more generally received opinion is that the specific infective processes are each due to a special form of organism, and that putrefaction serves only as a predisposing cause of infection : first by exciting inflammation and suppuration, and thus providing a suitable medium—the inflammatory exudation or pus—in which the pathogenic organisms may develop ; and secondly, by lowering the vitality of the tissues, in consequence of which they are more readily invaded by the pathogenic or parasitic fungi.

However this may be, the practical fact remains that the prevention of putrefaction is also the most certain means of preventing infection.

The mode of entrance of the virus has already been discussed (p. 181). In infective processes attacking wounds there is no doubt that in the great majority of cases, so great in fact that we may almost say in all cases, the virus enters the wound directly from without, and the surest means of prevention are those directed to protect the wound from external influences.

The local and general affections consequent upon septic processes in or infection of wounds may be thus briefly classified :—

I. **The Effects of Putrefaction.—True Septic Processes.**—The poison is generated solely in dead matter, and is associated with the presence of bacteria, bacilli, and micrococci of various forms.

a. **Local.**—*Septic inflammation and suppuration* dependent on the local irritation caused by the chemical products of putrefaction. It is a non-infective process (p. 182).

b. **General.**—A febrile affection dependent upon the absorption of the chemical products of putrefaction from the wound. It is a non-infective process, and varies in intensity with the dose of the poison. If the dose be small and the period during which absorption lasts be short, the resulting affection is known as *Septic Traumatic Fever* (p. 307) ; if the dose be small and absorption continue for months, it gives rise to *Hectic Fever* (p. 250). If the dose be very large and rapidly absorbed it may be speedily fatal, the affection then forming one variety of septicæmia—*Septic Poisoning*—or *Septic Intoxication*, or as it is sometimes called *Sapræmia*.

II. **Infective Processes.**

1. **Local Processes leading to a Spreading Destruction of the Affected Tissues.**

a. **Wound-diphtheria.**—This name has been applied by the Germans to a superficial infective process usually attacking granulating sores. The surface becomes covered with an opaque tough membranous layer, beneath which progressive destruction of the granulations takes place. There is febrile disturbance, but no specific constitutional affection accompanying it. It is contagious, and is associated with the growth of micrococci.

b. **Hospital Gangrene.**—A rapidly spreading gangrenous inflammation, attacking recent or granulating wounds. The gangrene follows closely on the inflammation, the dead tissues forming a pulpy adherent slough. There is febrile disturbance, but no specific infection of the whole system. It is associated with the growth of micrococci, and is intensely contagious.

c. **Spreading Traumatic Gangrene.**—An acute rapidly spreading inflammation terminating in death of the affected tissues. The inflammation extends a considerable distance beyond the dead tissues, and the gangrenous process is

accompanied by the evolution of gas and offensive decomposition. There is constitutional disturbance of the type of septic poisoning, but there is no evidence of a general specific infection of the blood. It is associated with the presence of rod-shaped organisms, but is not known to be contagious.

d. **Phlegmonous Erysipelas.**—An acute rapidly spreading inflammation of the subcutaneous areolar tissue, secondarily affecting the skin. It is accompanied by very abundant exudation, and the gangrene that complicates it seems to be due chiefly to the tension caused by this. So far as is known it is not accompanied by any specific infection of the system, and its contagiousness is doubtful. It is associated with the presence of micrococci in chains (streptococcus).

e. **Cutaneous Erysipelas.**—An acute infective disease characterized by a superficial inflammation spreading in the skin from the wound, and by a general febrile disturbance of a specific character. It is supposed by some that the poison infects the whole system as well as the local seat of inflammation, but this is doubtful. It is associated with the presence of micrococci in the affected skin, and according to some observers, also in the blood.

2. **General Infective Processes.**

a. **Septic Infection.**—An acute general infective process, rapidly terminating in death without the development of secondary centres of inflammation. The poison infects the whole system and increases in it, the fatal result being apparently directly due to alteration in the blood consequent upon the development of the virus in it. The local affection may be insignificant. The disease is rare in man. In animals it is easily induced experimentally, and in them it is always found to be associated with a definite organism in the blood, differing in different species. It is most intensely contagious. By many writers it is spoken of as *septicæmia*, its name being derived from the fact that in animals it is capable of being caused by the injection of small doses of putrid matter under the skin. The term *septic infection* is here used to distinguish it from *septic poisoning* caused by the chemical products of putrefaction, which by many writers is also spoken of as "septicæmia."

b. **Pyæmia.**—A general infective process, almost invariably starting from a wound which has reached the stage of suppuration; hence its name. It is characterized by the formation of secondary centres of inflammation and suppuration disseminated throughout the body. It is associated with the presence of micrococci in the blood and in the secondary centres of inflammation. It is believed to be contagious. It presents several varieties, which will be described when treating of the disease.

In actual practice it will be found that the distinction between these various affections is not always clearly defined, and this has given rise to the view that some of them at least are merely modifications of one disease. This apparent confusion may, however, be equally well explained by the co-existence of more than one form in the same case. Thus a patient may suffer from phlegmonous erysipelas with sloughing of the subcutaneous areolar tissue; decomposition of the sloughs may follow and give rise to septic poisoning, and, finally, death may take place from pyæmia.

c. **Anthrax, Glanders, Hydrophobia,** and **Tetanus.**—General infective diseases, the result of the presence in the body of a specific virus usually obtaining entrance in a wound. The three first-mentioned diseases have

been already described in Chapter XI.; tetanus will be considered in a subsequent Chapter.

It is impossible here to discuss fully the evidence for and against the micro-parasitic origin of these diseases. It is essential to bear in mind the four postulates which, according to Koch, must be fulfilled, before the causal relation of a micro-organism to any given disease can be taken as proved. First, the organism must be constantly present in cases of the disease; secondly, the organism must be capable of cultivation outside the body; thirdly, the disease must be capable of production by inoculation with the pure cultivation; and fourthly, the same organism must be capable of demonstration in the disease thus produced. Anthrax and cutaneous erysipelas may be quoted as instances in which these necessary conditions have been fulfilled, and, judging by analogy, the probability is great that in allied diseases the same proof will eventually be forthcoming. Further, the course of such diseases, the modifications produced by altered conditions in the body and in its surroundings, and lastly, the modes of prevention are all in keeping with the hypothesis of a living virus.

The chief arguments urged against it are the following. In the first place, it has been urged that many processes, dissimilar in every respect, are found to be associated with the presence of organisms apparently perfectly similar. Thus micrococci are found in a simple acute abscess, in erysipelas and in pyæmia; but with bodies of such extreme minuteness differences may readily exist which it is beyond our power to recognize. Cohn, while referring to this question, called attention to the external similarity of the sweet and bitter almond, which yet differ from each other so widely in their chemical properties. A much more important objection, which is pointed out by Koch himself, is that in many cases in the human subject the number of microscopic organisms found has been singularly small, so small in fact as to make it difficult to understand how they could be the cause of such grave disease. Lastly, it has been maintained that the microscopic organisms are merely an accidental accompaniment of the process and not the cause, or that at most they serve merely as carriers of the virus and are not the producers of it. It is difficult to refute this assertion with the means at present at our command. When, however, as in the case of erysipelas, the organism may be cultivated for twenty generations out of the body in an artificial medium, and finally, on being inoculated on another individual will produce a genuine attack of the disease, it seems difficult to regard it as other than an essential factor in the production of the specific inflammation.

It must be acknowledged therefore, that, although it is highly probable that all the diseases in this group arise directly from the action of micro-organisms, the evidence is not as yet sufficient to furnish in every case demonstrative proof of the truth of this theory.

Supposing, however, that the fungoid theory of infective processes in wounds were proved beyond a doubt, this would in no way disprove the facts previously known as to the influence of bad hygienic conditions in the development of these diseases. The experience of generations of Surgeons has taught us that, although inflammation and suppuration with febrile disturbance result from contact with the raw surfaces of wounds of such simple septic products as must form in all dead tissues or putrescible animal fluids exposed to the ordinary air of a dwelling-house, the graver infective processes are of

extreme rarity in cases treated in pure air and in the isolation of a private house. On the other hand, it has been established incontestably that if the cubic capacity of a ward be taken, and the rate of ventilation through it determined, a Surgeon may with certainty foretell how many suppurating wounds it will require, in the absence of antiseptic treatment, to generate infective disease in it.

Thus, although in the prevention of these diseases the use of antiseptics must take the first place as attacking the evil at its source, a strict attention to the laws of hygiene as regards cubic space, ventilation, and general cleanliness, is also necessary to exclude those accessory conditions that favour its development. By these means combined all this group of diseases can be prevented; their occurrence is the result in almost all cases of some definite error in the treatment of the wound, or of some infringement of sanitary rules. They are not accidental; they are preventable and ought to be prevented. Should a case arise, our knowledge of the nature of the diseases shows clearly how they may be carried from one individual to another, and efficient means to prevent their spread should at once be adopted. The whole subject of the relation of these diseases to general hygienic conditions has already been discussed (pp. 7 *et seq.*), and need not be further considered here.

The view is steadily gaining ground that the local and constitutional symptoms produced in septic and infective processes are the result of the action of chemical products developed during the growth of the micro-organisms. In the investigation of the nature of these chemical products much valuable work has recently been done and is still in progress. The most important fact, which may be taken as definitively established, is that in certain instances, the injection into the body of an animal of a culture of a pathogenic organism, from which the organism itself has been separated by filtration or destroyed by the action of heat, is still followed by the typical symptoms of the disease. This was first demonstrated by Pasteur in 1880, in connexion with chicken cholera; the symptoms of the disease followed the injection of the sterilized products of the bacillus.

In the consideration of Tetanus in the next chapter it will be seen that the characteristic symptoms of the disease can be produced by the injection of the "*toxines*" obtained from a pure cultivation of the tetanus bacillus. It may further be mentioned that paralysis has been produced in animals by the chemical products of the bacillus of diphtheria; coma, swelling of the spleen, etc., by those of the bacillus anthracis; and fatal septic intoxication by a definite chemical body obtained from putrefying blood.

The chemical products themselves belong to two chief classes: first, basic substances, which seem to be closely allied to alkaloids in their chemical composition; and secondly, toxic albumins, especially albumoses.

The relation of these chemical substances elaborated by the growth of pathogenic micro-organisms to the production of acquired immunity is one of great interest, but can only very briefly be referred to here. Pasteur supposed that immunity conferred by a previous attack of an infective disease resulted from the exhaustion of some nutritive material necessary for the growth of the micro-organism. Chauveau, on the other hand, held that it resulted from the retention in the blood of certain products produced by the organism and inimical to its own growth.

At the present day two chief views are held on this important subject.

According to Metchnikoff and his followers immunity is the result of certain changes imposed upon the living cells which act as phagocytes. In the Chapter on Inflammation (pp. 160 *et seq.*), it has been seen that the behaviour of leucocytes towards invading micro-organisms is possibly determined by the chemical products of the latter. If these are positively chemiotactic the leucocytes are attracted and the organisms destroyed by them; if on the other hand the chemical substances are negatively chemiotactic, the leucocytes are repelled and the micro-organisms gain the day. The same chemical product which in a susceptible animal acts negatively is supposed in the immune animal to act in a positive manner, and thus death of the invading organisms results.

On the other hand, Buchner and others believe that a bacteria-killing substance exists in the blood of immune animals, and that phagocytes play only a secondary part in the process, being attracted to the organisms which are already dead. Hankin has suggested that certain substances, which he speaks of as "protective proteids," are the essential agents, and are persistently in process of formation in the body of the immune animal.

LOCAL INFECTIVE PROCESSES IN WOUNDS.

WOUND-DIPHTHERIA.

This name has been applied by French and German writers to an unhealthy condition assumed by granulating wounds, in which they become covered by an opaque, white, or yellowish-white membranous layer closely resembling the false membrane of diphtheria. By English Surgeons it has more commonly been described as a mild form of phagedænic ulceration. It arises invariably in connection with decomposing discharges, and is not uncommon in wounds over which urine is flowing. The granulating sore which may have been in a healthy condition up to the time of the attack, becomes dark in colour, and here and there small hæmorrhages may be noticed amongst the granulations. The healthy discharge of pus ceases, and is replaced by a very slight serous exudation. Then an opaque white patch appears and soon spreads over the surface. The surrounding skin becomes reddened and slightly swollen, the edges are raised and sharply cut, and the sore may slowly spread and deepen. The opaque white layer on the surface is difficult to remove, but if a small piece be peeled off and examined microscopically it will be found to be composed of the superficial layers of the granulation cells which have perished and become finely granular, mixed with a coagulated exudation. Throughout the whole layer are abundant micrococci, singly, in chains, and in colonies. There is usually some slight febrile disturbance, and the nearest lymphatic glands are swollen.

Causes.—This unhealthy process is always the consequence of local neglect of cleanliness and general imperfection of hygienic arrangements. It may affect several wounds in a ward, but its contagiousness is not very clearly marked, and it frequently occurs in isolated cases. It has no relation to diphtheria. It is true that a similar unhealthy condition has been observed in wounds when the patient has been attacked by genuine diphtheria; but the constitutional condition is then entirely different. Diphtheritic inflammation in the throat does not lead to the progressive destruction of tissue

observed in the so-called wound-diphtheria. Wound-diphtheria is much more nearly allied to hospital gangrene; in fact, the term is extended by many writers on the Continent to that process, the affection here described being regarded as the mildest form of the same disease. It is well, however, to separate the process above described from genuine hospital gangrene, on account of its less evident contagiousness and its comparatively harmless character.

Treatment.—This is very simple. It is only necessary to apply some strong antiseptic lotion, such as chloride of zinc (gr. 40 to ℥j), carbolic acid (1 in 20), or the surface may be rubbed over with solid nitrate of silver or sulphate of copper. When a wound assumes this condition the hygienic surroundings of the patient should be carefully investigated, and any faults of ventilation, cleanliness or drainage corrected. In the mildest cases dusting the surface with iodoform may be sufficient to arrest the unhealthy process.

HOSPITAL GANGRENE.

This affection is also known by the names of contagious or pulpy gangrene, or sloughing phagedæna, and by some French and German writers the term wound-diphtheria is extended to it. It is characterized by a rapidly destructive and spreading infective inflammation, the affected wound becoming covered by an adherent slough as the process extends. It attacks open sores and wounds. It is rarely met with in its fullest extent, except in military practice; the accumulation of a large number of wounded persons with foul suppurating sores under one roof, and the want of proper cleanliness and attention during an active campaign, disposing to it.

LOCAL SIGNS.—When hospital gangrene invades a wound or open sore that has hitherto been perfectly healthy, grey soft points of slough appear upon it, which rapidly spread, until the whole of the surface is affected. At the same time the sore increases rapidly in superficial extent, and commonly in depth; the surrounding integument becomes œdematous, swollen, and of a livid red colour; the edges of the ulcer are everted, sharp-cut, and assume a circular outline; and its surface is covered with a thick pulpy greyish-green tenacious mass, which is firmly adherent. There is usually some dirty yellowish-green or brownish discharge, and occasionally some bleeding; the pain is of a severe burning character; and the fœtor from the surface is great. The ravages of this disease, when fully developed, are very extensive. The soft parts, such as the muscles, areolar tissue, and vessels are transformed into a grey pulpy mass, and the bones are denuded and necrosed. The larger blood-vessels resist the progress of the disease longer than any other parts, but may at last be exposed, pulsating at the bottom of the deep and foul chasm. There is, however, little risk of hæmorrhage in the early stages; but, when the sloughs are separating, an artery may give way, and bleeding to a dangerous or fatal extent ensue. Hennen states that there is most danger of this about the eleventh day. When the sloughs are thrown off, in the form of reddish-brown or greyish-green, viscid, and pulpy masses, a very sensitive granulating surface is left, having a great tendency to bleed, and to be again invaded by the gangrenous process.

Blackadder has described a form of this affection, in which a vesicle containing a bloody ichor forms, with a hot stinging pain; this breaks, leaving a

circular ulcer of about the size of a split pea. The ulcer once formed, rapidly extends by sharp-cut edges into the surrounding integument.

Constitutional Symptoms.—In the early stage there may be active febrile disturbance, with high temperature and quick pulse. But these symptoms soon subside into those of prostration. In the majority of cases the constitutional symptoms follow the local invasion of the wound. This was certainly so on the two occasions in which in former years I had an opportunity of observing outbreaks of the disease in University College Hospital; and the same has been noted by Delpech, Blackadder and others.

Causes.—All wounds and sores are liable to be attacked in this way, but the disease most frequently affects those that are of recent origin. Hutchinson believes that it is specially prone to originate in syphilitic subjects. The experience of many wars has led incontestably to the conclusion that hospital gangrene will certainly be developed amongst the wounded if they are crowded in too great numbers under one roof, however large may be the building; whilst, amongst the wounded who are treated in the open, or in "hut hospitals"—mere temporary sheds—it is all but unknown. In many German hospitals in which it was formerly of very frequent occurrence, it has been entirely excluded by the adoption of antiseptic methods of treating wounds, all other conditions remaining unchanged. It is evident, therefore, that the disease is primarily due to two causes, the overcrowding of patients in a ward and the putrefaction of the discharges from their wounds. The last outbreak that occurred at University College Hospital, more than twenty-five years ago, was evidently due to these causes. In one of my wards, which was intended to contain 15 or 16 patients only, owing to accidental and unavoidable circumstances, 21 patients were admitted, and slept for one night, many of them having suppurating wounds. The result was an outbreak of hospital gangrene, which spread through the institution, and was most serious and persistent. But though it commonly has its origin in this way, especially in the crowding of military hospitals after a hard-fought action, it is met with out of hospitals. Well-marked cases of this affection, some of a very severe character, have at times occurred amongst the out-patients of University College Hospital. In these cases, as in many others, it is probable that the disease was occasioned by the neglect of hygienic conditions, in the close and ill-ventilated houses of the poor, aided possibly by some atmospheric or epidemic influence; erysipelas and phlebitis being also very prevalent at the time. This had been observed during the first occurrence of the disease at our Hospital, in 1841; and it is impossible not to recognize a similarity of cause in these different affections. Hospital gangrene is highly contagious, and when once it has broken out it will readily spread from patient to patient by contact with nurses' or Surgeons' fingers, instruments, dressings, and above all if the pernicious custom of using sponges in cleaning sores be adopted. It is impossible to be too careful in these respects. The disease may also be carried by the air, and may thus be said to be "infectious."

Pathological Anatomy.—The slough is composed of the tissues of the part infiltrated with inflammatory products, the fluids having undergone coagulation. The individual cells are not recognizable, the whole presenting a finely granular appearance. When stained and properly prepared, innumerable micrococci are seen amongst the granules; they are in colonies or chains, or single. The perishing tissues immediately beneath the slough are

infiltrated with migrating cells, which press upon the vessels, some of which are obliterated, and others filled with clots. Micrococci are recognizable in this region also, and are almost certainly directly concerned in causing the unhealthy process. Koch succeeded in inducing in mice a gangrenous process closely resembling hospital gangrene by the inoculation of a form of micrococcus which showed a regular mode of growth in chains. The infective process was purely local, death occurring without infection of the blood. The micrococci were originally obtained from putrid blood, but subsequent inoculations from one animal to another were constantly followed by the same form of gangrenous inflammation, and the development of the same definite form of micrococcus.

TREATMENT.—The **preventive treatment** of hospital gangrene may be deduced from a consideration of the causes that give rise to it. The experience of many German surgeons, and especially of Nussbaum, of Munich, has shown, that by the introduction of the antiseptic treatment the disease has been banished from hospitals in which, owing to faulty hygiene, it formerly existed to a fearful extent. On the other hand, it had practically been banished from English hospitals by attention to ordinary cleanliness, and general hygienic rules as to cubic space per patient, ventilation, drainage, &c., long before the introduction of antiseptic surgery, although occasional outbreaks still occurred. Now it is unknown in any properly managed civil hospital. In military practice antiseptic treatment is often impossible, and overcrowding unavoidable. The disease may then be prevented almost to a certainty by treating the wounded under canvas, in "hut hospitals," or in the open. Should it break out, the building in which it has developed itself should at once be abandoned or destroyed. The spread of the disease may be prevented by at once isolating the affected patient, treating him in the open, and allowing no contact between his attendants and other patients. Should it have broken out in a civil hospital, the first point to attend to is to *prevent the extension of the disease* to patients who are not as yet affected. This may be done by separating those who have been seized with it from the healthy, by preventing overcrowding of the hospital, ventilating the wards, washing the floors with a solution of chloride of zinc, whitening the walls, and fumigating the apartment with chlorine gas.

Local Treatment.—The first step in the local treatment is, to clean away the slough till the living tissues are exposed, the patient being under the influence of an anæsthetic. This must be done by means of scissors and forceps, by scraping with a sharp spoon, and by forcibly rubbing the surface with a sponge or a piece of tow. The metal instruments used for this purpose must afterwards be disinfected by being held in the flame of a spirit lamp, or put in a bath of carbolic lotion (1 in 20); the sponge or tow must *immediately* be burnt. The raw surface must then be freely cauterized by the application of fuming nitric acid, chloride of zinc, or the actual cautery. I prefer nitric acid, if strong and freely applied, the surface and edges being well sponged with it. The actual cautery is, however, very useful in those cases in which the surface to be destroyed is very extensive, or if there be a tendency to hæmorrhage. Should it not reach the deeper portions of the sore, nitric acid may be freely sponged into them. It is important to bear in mind that these escharotic applications will be fruitlessly expended in charring the tenacious grey pulpy slough, unless this have been previously cleared away. After the

application of the caustic, the parts may be dressed with carbolic oil, terebene and oil, or some moist antiseptic dressing. The German Surgeons, who until recently had unusual opportunities of studying this affection, mostly preferred chloride of zinc. König recommends the following treatment. The sloughs having been cleared away, the surrounding skin must be washed with carbolic acid lotion (1 in 20), or chloride of zinc (20 gr. to ℥j). Some dry chloride of zinc is then moistened with water till it dissolves into an oily liquid; cotton-wool soaked in this is laid on the raw surface, and pushed into any irregular hollows or cavities of the wound, and allowed to lie there for from five to twenty minutes, according to the severity of the case. It is then removed, and some efficient form of antiseptic dressing applied. The pain is usually severe, and a hypodermic injection of morphia should be given to relieve it. The slough formed by the chloride of zinc will separate in from three to ten days, leaving a healthy granulating surface beneath, which may be treated on ordinary principles. In military practice, in which alone it is probable that hospital gangrene will be met with in the future, chloride of zinc is by far the most convenient caustic, as it is carried in the solid state, while fuming nitric acid is dangerous and difficult to transport.

Should *arterial hæmorrhage* occur, it may be arrested by the application of a ligature to the bleeding point; but if this do not hold, as will probably be the case owing to the softened state of the tissues, the actual cautery must be applied; or the limb must be removed if all other means fail.

In some cases, though the sloughing is checked at one part of the surface, it has a tendency to spread at another. When this is the case, it may be necessary to apply the caustic or cautery repeatedly. In other instances, the sloughing cannot be stopped, but opens large arteries, and destroys the greater part of the soft tissues of a limb; and then it may be a question whether amputation should be performed during the spread of the disease, or the patient left to die of hæmorrhage or exhaustion. Such a contingency is not of common occurrence; yet it may happen and the operation be successful as appears from the following case, though there would necessarily be great danger of a recurrence of the disease in the stump. The wife of a butcher applied at the Hospital, with a slight wound of the forearm, inflicted by a foul hook. It was dressed in the ordinary way, but in the course of a few days she returned with extensive sloughing phagedæna of the part. She was immediately admitted, and the disease was arrested by the energetic employment of the local treatment above described; not, however, until after considerable destruction of the tissues on the inside of the forearm had taken place. She left the Hospital before the wound was completely cicatrized, and returned in a few days with a fresh attack of the disease, more extensive and severe than the first; this time the process could not be permanently stopped, either by the actual cautery or by nitric acid. The radial artery was opened and required ligature, and the whole of the soft parts, from the wrist to the elbow, were totally disorganized, and the bones exposed. There was now very severe constitutional disturbance, and the case was evidently fast hastening to a fatal termination. In these circumstances I amputated the arm midway between the shoulder and the elbow; and, notwithstanding that the local disease was progressing at the time of the operation, and that the constitutional disturbance was very great, the patient having a pulse of 160 to 170, at which it continued for more than a fortnight, she made a good recovery. To

this the free administration of quinine and stimulants greatly contributed.

The **Constitutional Treatment** consists in as nourishing a diet as the patient will take, with a liberal supply of stimulants ; and these may be increased by the addition of the brandy-and-egg mixture, or of ammonia, in proportion as depression comes on. From five to seven grains of the sulphate of quinine should be given every four or six hours, with a full dose of opium at bed-time, and more frequently if there be much pain and irritation.

SPREADING TRAUMATIC OR EMPHYSEMATOUS GANGRENE.

Spreading Traumatic Gangrene, Emphysematous Gangrene, or the *gangrène foudroyante* of Maisonneuve, is a most acute and fatal form of infective inflammation usually following contused or lacerated wounds, particularly when complicated with fractures or when opening a joint.

Causes.—The causes of the disease are not certainly known. The cases occur sporadically and there is no evidence of infection from case to case. It is met with at all ages. On examination of the affected tissues, rod-shaped organisms — bacteria — are found in great abundance, and these are doubtless connected with the rapid formation of offensive gas in the gangrenous parts which forms so characteristic a feature of the disease. They have also been found in the blood, probably not in an active state, but being merely accidentally present. In the great majority of cases the wound from which the gangrene has originated has not only been lacerated but has had mud or dirt, especially street mud, ground into it. This is known to contain rod-shaped organisms, both bacilli and bacteria, capable of setting up various unhealthy local and general processes if inoculated on animals, and it is very probable that this is the source of infection in cases of emphysematous gangrene. The conditions favourable for the development of the disease are the presence of the lacerated wound opening a cavity such as a joint or communicating with a crushed bone. It is especially liable to occur if the wound be injudiciously closed by sutures without proper drainage or antiseptic precautions.

Fig. 340.—Bacteria cultivated on a potato from a case of emphysematous gangrene.

It is most common after contused or lacerated wounds of the foot with considerable subcutaneous extravasation ; it also occasionally follows similar injuries of the hand.

Symptoms.—Spreading gangrene always sets in before suppuration is established, usually on the second or third day. At first the symptoms appear to be merely those of ordinary septic inflammation, the result of pent-up decomposing discharges. There is febrile disturbance of the septic type, with pain and swelling in the wound, and a blush of redness extending for some distance on each side of it. The true nature of the affection, however, speedily becomes apparent. The wounded limb at the seat of injury swells, becomes dusky-red, and is the seat of a deep-seated, burning pain. The

swelling, redness, and tension spread upwards, and are speedily followed by a dusky purplish tint, by a soft doughy feeling of the parts, and in the course of a few more hours by a deep blackish-purple discoloration, which spreads uniformly and with great rapidity through all the tissues affected. This is accompanied or immediately followed by emphysematous crackling, due to the presence of gases which are developed by the decomposition of the parts attacked by the gangrene. The changes, which are of a putrefactive nature, first develop in the wound itself, and speedily extend from it to the surrounding parts. That portion of the limb which is below the gangrenous part becomes pale, cold, and œdematous. The portion which is above becomes rapidly infiltrated by serous exudation, which runs up the inner side of the limb to the axilla or groin, as the case may be. The part immediately above the limit of the tissues that are actually mortified is swollen by œdematous infiltration, tense, pitting slightly on pressure, and usually of a dusky brownish-red colour; and frequently beyond the edge of the advancing redness, there is a brownish discoloration, apparently due to pigment liberated by the breaking up of the red corpuscles in the gangrenous tissues and diffused beyond the area of inflammation. The process has no tendency to limit itself; the œdema and peculiar discoloration extend higher along the inner side of the limb, where they always first reach the trunk. Emphysematous crackling rapidly spreads along the same parts, and the gangrene here travels with great rapidity, hopelessly involving the tissues and entering into the areolar planes of the axilla or groin in a very few hours. As the gangrene advances, the parts affected are transformed into a soft, pulpy, black mass. On making an incision into the parts so affected, it will be found that the gangrenous inflammation is primarily seated in the areolar planes of the limb, and that the muscles are not affected in the first instance. It will be observed also that the disease extends through the areolar tissue, the skin falling secondarily into slough.

The constitutional symptoms early assume the character of acute septic poisoning, the patient sinking into a prostrate condition, and the temperature falling below normal. Unless relieved by treatment, death almost invariably ensues in three or four days after the invasion of the disease, and always shortly after the gangrene has reached the trunk.

Treatment.—The preventive treatment consists in very carefully cleaning any wound into which mud or dirt has been ground with a powerful antiseptic fluid, perchloride of mercury (1 in 500) perhaps being the best. Should emphysematous gangrene appear the Surgeon will be placed in a great difficulty. If he trust to constitutional treatment, in the hope of a line of demarcation forming, he will certainly be disappointed, the gangrene rapidly spreading up to the trunk; and if he amputate, he will probably lose his patient by the stump becoming affected. Yet amputation should, in my opinion, be performed at once. For, although this operation is necessarily very unfavourable when practised in these cases, yet it must be remembered that, if the Surgeon wait for the line of demarcation or trust to other means such as incisions or general treatment, the patient will certainly die. The only chance of safety, then, lies in amputating early, and removing the limb high above the part affected; thus, in spreading gangrene of the arm, at the shoulder-joint; and of the leg, in the upper part of the thigh. In most cases it will be found that the infiltration precursory to the gangrenous mischief runs up one side of the

limb—the inner or posterior—to a much greater extent than the other. In amputating under such circumstances, the Surgeon may often very advantageously so fashion his flaps as to exclude as much as possible of the affected part or side of the limb, forming them chiefly from that least affected. The principal source of danger, after amputation in these cases, is recurrence of the morbid condition in the stump, more particularly in the lower extremity. Out of twelve cases in which I have seen or done amputation for this disease this recurrence happened in seven instances. The tendency will be increased by the proximity of the line of amputation to the gangrenous limit. But, even under the most unfavourable circumstances, recovery will sometimes take place. Thus I have seen the flaps in amputation for spreading gangrene infiltrated with gelatinous-looking fluid, and yet recovery take place. In a man whose arm I amputated at the shoulder-joint for spreading gangrene of the limb, the infiltration had extended as high as the scapula; yet he made an excellent recovery. In the lower extremity the liability to recurrence of the gangrene is, however, very much greater; and there can be but very little prospect of saving the patient if the thigh has once become reddened and infiltrated, even though the gangrene do not extend above the knee—invasion of the stump ensuing under such circumstances with almost absolute certainty.

Much of the success of the case will depend on the after-treatment. This must consist principally of antiseptic dressings to the stump, full doses of liquor opii, and the early and free administration of stimulants, more particularly brandy and wine; attention to these points will often bring the patient through, though usually not without much difficulty and great constitutional disturbance.

CHAPTER XXXII.

ERYSIPELAS. CELLULITIS. WHITLOW.

THE term "erysipelas," or "erysipelatous inflammation," is applied to a group of infective inflammatory processes affecting the skin, the subcutaneous areolar tissue, intermuscular or subfascial areolar tissue, mucous membranes and submucous tissue, serous membranes and lymphatic vessels, and having one feature in common, *the tendency to spread with great rapidity by continuity of tissue, or in other words, to assume a "diffuse" form.* Erysipelas is due to the action of a virus, which infects the part attacked, increases in quantity in it by a process analogous to fermentation, and diffuses itself by means of the lymph-spaces and lymphatic vessels, exciting a characteristic form of inflammation as it spreads. The virus most commonly enters the body by a wound, causing a local inflammation accompanied by a definite febrile disturbance; but some forms of erysipelatous inflammation arise when no apparent wound exists, and it is probable that in such cases the poison enters the system from the alimentary canal or the respiratory tract, and is carried by the blood to the spot at which the local inflammation appears. There is no evidence of a true general infection in any of the forms of erysipelas; it is probable that the virus may be carried by the blood, but cannot multiply in it as in a true general infective process.

Erysipelatous inflammation may attack a wound of any size or of any age; but the statistics of University College Hospital show that it most commonly arises in suppurating wounds, about two-thirds of the cases beginning after the tenth day, and very few before the fourth.

The different forms of erysipelatous inflammation are most conveniently described as they affect different tissues and organs. With this view, we may divide them primarily into External and Internal Erysipelas.

External Erysipelas is that variety which affects the skin and subcutaneous areolar tissue. The inflammatory process may affect either or both of these structures and thus erysipelas has been divided, as first suggested by Nunneley, into three forms: 1. **Cutaneous;** 2. **Cellulo-cutaneous;** 3. **Cellulitis**. The cellulo-cutaneous form is the **Phlegmonous Erysipelas** of Lawrence; whilst the cellular variety is often spoken of as **Diffuse Cellulitis.**

It is a fact of much importance that the cutaneous variety of erysipelas is characterized by the absence of pus formation, whilst on the other hand the cellulo-cutaneous and cellular varieties are essentially processes of diffuse suppuration. We shall indeed see shortly that there is strong clinical and pathological support for the view that cutaneous erysipelas is a specific inflammation of the skin, and that the conditions known as cellulo-cutaneous and cellular erysipelas are quite distinct affections resulting from infection of the tissues with pyogenic organisms, and differing from each other chiefly in the exact seat of the suppuration.

The statistics of University College Hospital give the following results, showing the relative frequency of these affections. During a period of ten years 196 cases were admitted under the care of the Surgeons or arose in the surgical wards. Of these 148 were cutaneous, 24 cellulo-cutaneous or phlegmonous, and 24 cellular (or cellulitis). To these may be added 36 cases of so-called idiopathic cutaneous erysipelas admitted under the care of the Physicians, making a total of 184 cases of the cutaneous form out of 232, or nearly 80 per cent.

Causes.—The causes of erysipelatous inflammations are: first, the *essential cause*, the virus or contagium; and secondly, the *predisposing causes*, which may be divided into those that are *intrinsic* to the patient, including such local or constitutional conditions as predispose him to receive the virus, and those that are *extrinsic*, such as the meteorological and hygienic conditions to which he is exposed before he is attacked by the disease. The extrinsic causes may act by favouring the development of the virus out of the body or its transmission from one individual to another, or by impairing the health of the patient and thus rendering him more ready to receive the poison.

1. The **Essential Cause.**—It has been proved to demonstration that *cutaneous erysipelas* is the result of the growth of a micrococcus in the lymphatic spaces of the skin. The organism occurs most commonly in pairs or chains, and is known as the Streptococcus erysipelatosus. Fehleisen first succeeded in cultivating these organisms on gelatine and coagulated serum. A small piece of the affected skin was removed and placed on the prepared gelatine; after a short time the white film, which the microscope showed to be composed of micrococci, spread over the surface of the gelatine. A small speck of this was then planted on another gelatine surface and again the film formed. This process was repeated many times, in one instance to thirty generations, until it might reasonably be supposed that any chemical poison which might theoretically have been adhering to the original organisms taken from the skin was perfectly eliminated. The fungi were then inoculated on rabbits, and gave rise to a spreading inflammation, exactly resembling cutaneous erysipelas. Afterwards similar inoculations were made on eight patients in cases of cancer, sarcoma, and lupus, with the view of exerting the reputed curative action of erysipelas on these affections. Seven out of the eight patients, after a period of incubation of from fifteen to sixty hours, were affected by genuine erysipelas, with all the characteristic local and constitutional symptoms. In the one case in which the inoculation failed, the patient had recently recovered from a spontaneous attack of the disease. At the Congress of German Surgeons in 1883, Fehleisen exhibited a patient in whom genuine cutaneous erysipelas had been produced by the inoculation of micrococci which were thirty generations removed from the original organisms obtained from the skin, the cultivation having been continued on gelatine from August, 1882, to April, 1883.

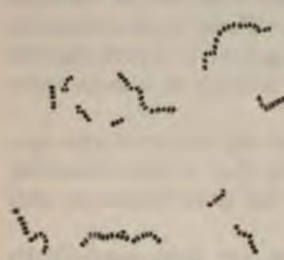


Fig. 341.—Streptococcus erysipelatosus. (From a pure cultivation on gelatine.)

According to Koch and Fehleisen, the micrococci are not found in the

blood-vessels or blood. Hiller states that if the blood be examined numerous white corpuscles in a state of degeneration are found, having become converted into masses of highly refracting granules. Busk has described the occurrence of plugs of such corpuscles in the capillaries of the lung, and Bastian has observed a similar condition in the brain.

In *phlegmonous erysipelas* and in *diffuse cellulitis* a micrococcus is also found—the Streptococcus pyogenes—which has already been described on p. 244.

Fig. 342.—Pus from a case of Phlegmonous Erysipelas, containing the Streptococcus pyogenes.

Much discussion has taken place as to the possible identity of these two organisms—the Streptococcus erysipelatosus and the Streptococcus pyogenes. In their microscopic characters and in their behaviour in artificial cultivations the two organisms are practically indistinguishable. The results of inoculation experiments have been somewhat contradictory; thus while several observers have obtained similar results with the two organisms, others have found that the Streptococcus erysipelatosus constantly causes a spreading inflammation of the skin, but that the Streptococcus pyogenes causes marked inflammatory swelling with a tendency to suppuration. Baumgarten and others who believe that the organisms are identical suggest that the clinical differences between cutaneous erysipelas and the suppurative processes are dependent upon the varying virulence of the organism, the mode of infection and the idiosyncrasy of the patient. On the whole it seems probable that the two organisms, although morphologically alike, are not the same. Watson Cheyne, who inclines to this view, suggests that cases in which cutaneous erysipelas and suppuration are associated may be the result of mixed infection.

It is an important fact to guide us in the prevention of these diseases that the organisms are killed in 45 seconds by a 1 in 30 solution of carbolic acid, or in 15 seconds by a 1 in 1000 solution of corrosive sublimate.

Cutaneous Erysipelas is undoubtedly *contagious*, and instances have repeatedly fallen under my own observation, in which erysipelas, often unfortunately fatal, has been communicated to the servants, nurses, or relatives of patients affected by it. A remarkable proof of the contagious nature of erysipelas occurred in the winter of 1851, in one of my wards at University College Hospital. The Hospital had been free from any cases of the kind for a considerable time, when, on the 15th of January, at about noon, a man was admitted under my care with gangrenous erysipelas of the legs, and placed in Brundrett Ward. On my visit two hours after his admission, I ordered him to be removed to a separate room, and directed that the chlorides should be freely used in the ward from which he had been taken. Notwithstanding these precautions, two days after this, a patient, from whom a necrosed portion of ilium had been removed a few weeks previously, and who was lying in the bed adjoining that in which the patient with erysipelas had been temporarily placed, was seized with erysipelas, of which he speedily died. The disease then spread to almost every case in the ward, and proved fatal to several patients who had recently been operated upon.

Phlegmonous erysipelas and diffuse cellulitis on the other hand do not spread by infection if a case be admitted into a general ward; nevertheless, on

account of the somewhat uncertain state of our knowledge concerning these affections, the patient should if possible be isolated.

2. **Predisposing Causes.**—Certain local and constitutional intrinsic causes predispose the patient to receive the virus.

Local.—Of these the most important is certainly *the presence of a wound* or *raw surface*. The statistics of University College Hospital show that erysipelatous inflammation may attack a wound at any time from its infliction to its healing. This is especially true of the cutaneous forms; other varieties of erysipelatous inflammation more commonly start from recent wounds. The presence of decomposing discharges in the wound is undoubtedly an important predisposing cause, and antiseptic treatment has done much to prevent it. When erysipelas is epidemic, it is well for the Surgeon not to perform any operation that can conveniently be postponed; and in no case should a patient on whom an operation has recently been performed be put in a neighbouring bed to a case of erysipelas, or even in the same ward. The size of the wound has little influence on the occurrence of erysipelas, which will as readily follow a puncture as an amputation wound. Lacerated wounds are, however, more liable to be followed by erysipelas than clean-cut incisions. The depth of the wound also influences in an important manner the kind and the degree of the erysipelatous inflammation, the phlegmonous and the cellular forms arising most commonly from those injuries that penetrate the deep fascia of a limb. In such cases the disease may spread widely and fatally through the deeper subaponeurotic and intermuscular planes of areolar tissue. It is important in these cases not to confound a simple septic inflammation due to the presence of decomposing matter in an ill-drained wound, with genuine erysipelatous inflammation. Injuries about the head and hands are said to be more liable to be attacked by erysipelatous inflammation than those of other parts.

Constitutional.—Some persons appear to be *naturally predisposed* to erysipelas to such a degree that it readily follows the application of cold, or stomach disorder, or a trivial superficial injury. This predisposition is most generally acquired by habitual derangement of health, more especially as the result of the excessive use of alcoholic stimulants. The condition is met with amongst the labouring poor as the result of privation of the necessaries of life, and amongst the wealthier classes as a consequence of high living, want of exercise, and luxurious habits.

Some *morbid states of the blood*, consequent upon visceral disease, appear to predispose, in the highest degree, to the supervention of erysipelas. This is especially the case in diabetes, and in disease of the kidneys attended with albuminuria. As a consequence of renal disease, erysipelas often occurs from the most trivial causes; such as a scratch, the sting of an insect, or any of the minor operations in surgery, more especially about the lower part of the body. Not only is it readily induced in this way, but it will extend in an uncontrollable manner in these states of the system, and will often assume a gangrenous form, there being apparently an utter want of power in the tissues to resist the influence of the virus. Persons of a plethoric habit, with a tendency to gout, are predisposed to erysipelas. The blood-degeneration that attends malignant disease peculiarly disposes to erysipelas, which accordingly more frequently takes place after operations on persons suffering from such diseases than after the removal of simple tumours.

Persons whose *nervous systems* are habitually depressed, the semi-idiotic and idiotic for instance, are very prone to inflammations of an erysipelatous form. A person who has once suffered from erysipelas is said to be more liable to the disease. Fehleisen states that his inoculation experiments showed that after an attack of cutaneous erysipelas there is a short period of immunity, lasting a few weeks or months.

2. **Extrinsic Causes.**—Amongst the circumstances that surround the patient and that favour the production of this disease, the season of the year and atmospheric changes exercise a marked influence. Erysipelas is usually supposed to be more frequent in the spring and autumn, and the experience at University College Hospital tends to confirm this idea. Thus we find that during the years 1871 to 1890, 471 cases of erysipelas were treated in the Hospital, including those admitted for the disease and those affected by it while undergoing treatment for other affections. Of these, 126 occurred during the cold months of December, January, and February; 129 during March, April and May; 74 during the hot months of June, July, and August; and 142 during September, October, and November. It has frequently been asserted that erysipelas often breaks out on the setting in of cold easterly winds or on sudden atmospheric changes. Observations were made during one year (1872) at University College Hospital with the view of testing the truth of this assertion; but, as they were not continued after that year, the time over which they extend is not sufficient to exclude the influence of chance. As far as they went, however, they tended to show that mild damp weather, with westerly winds, is a more powerful predisposing cause of erysipelas and allied conditions than cold dry weather with easterly winds, which is exactly the reverse of the generally received opinion. The subject is one of great interest, and is well worthy of further investigation. Erysipelas often becomes epidemic as the result of peculiar, but at present unexplained, conditions of the atmosphere. Thus at University College Hospital the number of cases occurring during the four years 1871 to 1874 was as follows: in 1871, 29; in 1872, 29; in 1873, 26; in 1874, 67. And not only was it at University College Hospital that this excess of erysipelas was noticed, but every similar institution in London suffered in the same way. It will usually be found that, when erysipelas is very abundant among the in-patients of a hospital, similar cases present themselves for treatment in the out-patient department; and at the same time it is generally noticed that phlebitis of varicose veins, epidemic catarrh, acute tonsilitis, and other allied affections prevail. Epidemic erysipelas may vary in its type. Thus the epidemic of 1874 was chiefly of the cutaneous variety, and was accompanied by comparatively slight tendency to gangrene or sloughing; while that of 1872, in Edinburgh, was of a violent phlegmonous type, usually attacking the subcutaneous tissue and leading to extensive diffuse sloughing and suppuration.

The great predisposing cause of erysipelas is, however, to be sought for and will be found in a *want of attention to hygienic conditions*. It is one of the penalties inflicted by nature on those who neglect those prime requisites of health—temperance and cleanliness—or who are incapable of obtaining good food and pure air. Were the laws of hygiene obeyed as they should be, erysipelas and the allied diffuse inflammations would rarely be met with in surgical practice. *Overcrowding* of hospitals, and *want of proper ventilation* in wards and rooms, are fertile sources of erysipelas, and of the allied processes.

Erysipelas, however, cannot be as certainly generated in this way as some other unhealthy processes in wounds, such as hospital gangrene, or pyæmia. This has frequently been observed in military practice. Thus, after the battle of Sedan, although the wounded in some hospitals were almost decimated by pyæmia, erysipelas was very rarely met with. In the American War it is stated to have occurred in 0·4 per cent. of the wounded. It generally broke out in badly ventilated hospitals, and spread rapidly from one patient to another. It was less frequent in cases treated in tents, but occasionally it made its appearance under the most favourable hygienic conditions. These facts tend to confirm the view that genuine erysipelas is due to a specific virus which is not universally present. In old hospital buildings in which the disease has frequently occurred, the poison may be constantly present, waiting only for favourable conditions to manifest itself.

Fehleisen has shown that the streptococci of cutaneous erysipelas can be cultivated at ordinary temperatures, not only in gelatine and blood-serum, but on potatoes, and it seems probable that the virus will increase readily whenever there is dead animal or vegetable matter in which it can develop. This explains the way in which the disease is not unfrequently originated in hospitals, by dressers going directly from the dead-house, and especially from the examination of the bodies of those who have died of diffuse inflammations, to the bedside of patients, without taking sufficient care to clean their hands or change their clothes. For this reason also the same instruments should never be used for practising operations on the dead and performing them on the living body. The apparent origin of the disease from air passing over an ash-heap on which kitchen refuse has been thrown, which has been more than once recorded, may be due to the cultivation of the specific streptococcus on decaying vegetable matter.

The varieties of external erysipelatous inflammation will be separately discussed in some detail.

1. Cutaneous Erysipelas is a specific spreading inflammation of the skin, accompanied by constitutional symptoms which are secondary to the local disturbance.

Local Symptoms.—If there be a wound, its surface becomes dry, and the margins become slightly swollen, and the characteristic rash spreads away from them into the surrounding skin. The disease may also appear to occur idiopathically; that is to say, it may apparently originate in the unbroken skin. Trousseau, and others, have asserted that even in these cases it always starts from some slight abrasion which has been overlooked. When arising in this way it commences most commonly at the junction of mucous membrane and skin, as at the angle of the mouth, the ala of the nose, the corner of the eye, the meatus of the ear, or the margin of the anus. In rare cases it may arise spontaneously on the limbs. I have seen it commence in the unbroken skin over an abscess. This so-called idiopathic erysipelas is the same disease as that in which the rash starts from a wound, although this has been doubted. During an outbreak of erysipelas in a surgical ward the two forms may arise in different cases as the result of the same infection.

The *rash* is of a uniform, vivid rosy-red hue, sometimes becoming dusky, and always disappearing on pressure, leaving a slightly yellowish tint behind; when advancing, it is characterized by a sharply-defined border slightly raised above the healthy skin, but when subsiding it fades away into the colour of the

healthy skin. It is accompanied by some slight œdematous swelling, frequently recognizable only by the permanent impression left by the finger-nail pressed on the skin, but often considerable where the areolar tissue is loose, as in the eyelids and scrotum; and there is usually a sense of stiffness with a burning sensation in the part, and not unfrequently greatly increased sensibility. Vesicles or bullæ often form, containing a clear serum, which speedily becomes turbid, and dries into fine branny desquamation. The redness may spread rapidly along the limb or trunk, or if the face be affected, may travel quickly from one side to the other, causing such swelling of the eyelids as to close them, and giving rise to swelling and much tensive pain in the ears. The disease is invariably accompanied by enlargement and tenderness of the lymphatic glands. In some cases this may even precede the rash.

A form termed *erratic erysipelas* has been described occurring in connection with pyæmia, in which the eruption disappears from one part of the body and reappears in another. It is a very dangerous condition, often indicating the approach of death. It is very doubtful if it is in any way related to genuine cutaneous erysipelas.

The inflammation in cutaneous erysipelas has no tendency to terminate in suppuration. In some parts in which the areolar tissue is very loose, especially in the eyelids, suppuration occasionally takes place, but it then seems to be the result rather of the tension caused by the effusion than of the irritation of the specific virus.

When the inflammation is passing off the pain abates, the colour fades, the swelling subsides, the cuticle, which has been detached by the serous transudation, flakes off in thin layers, and the skin returns to its normal state. In other cases, œdema of the part continues, with some irritability and redness of the skin and peeling of the cuticle; and in some rare cases the simple erysipelas seems to take on a gangrenous or sloughing character, especially about the umbilicus and genitals of young children.

Constitutional Symptoms.—The fever of cutaneous erysipelas continues as long as the rash is spreading. The invasion is marked by alternate chills and flushes, but seldom by a distinct rigor. The temperature seldom rises to 106° F., more commonly it keeps below 104° F. There are no marked variations beyond the ordinary morning fall and evening rise met with in all febrile affections. The pulse may at first be full and strong, but it soon falls in force and becomes more frequent. Headache is a common symptom. There is frequently some delirium, which in the early stages may be violent, but later on becomes feeble and muttering. Delirium is especially marked in erysipelas of the head, and was formerly supposed to be due to affection of the membranes of the brain. It has been shown, however, by *post-mortem* examination of fatal cases, that meningitis is very rare except in cases of erysipelas attacking a compound fracture of the skull, or spreading into the fat of the orbit. The delirium is usually due to the blood-condition, and is always a grave sign. The tongue is at first much coated, and soon becomes dry and brown; there is also in most cases a good deal of derangement of the digestive organs, with tenderness about the epigastrium, complete loss of appetite and nausea; the evacuations are dark and offensive, and not unfrequently there is diarrhœa.

Cutaneous erysipelas is a most depressing disease, the patient being frequently much reduced in strength, anæmic, and emaciated even after a comparatively slight attack.

The duration of an attack of cutaneous erysipelas is very uncertain; it may last from three days to three weeks, and relapses by which it may be prolonged to a month or more are very common.

Pathology.—After death the red tint fades, leaving the skin of a yellowish tint; if it be cut into, it is found to contain an excess of serous fluid. The internal organs present nothing that is characteristic. As in all diseases accompanied by high fever and general blood-poisoning, the epithelium of the kidneys and liver is found in a state of cloudy swelling, and the spleen is in some cases enlarged. The lungs are usually congested. Sometimes marked *post-mortem* staining of the blood-vessels and organs is found very soon after death, and occasionally small petechiæ are scattered beneath the serous membranes.

If the most advanced edge of the spreading margin be examined microscopically, the lymph-spaces of the cutis are found to contain numerous streptococci, as was first pointed out by Lukomsky and v. Recklinghausen. These may be packed so closely as to form an opaque granular mass, but if they are less crowded together they can be seen to form pairs or

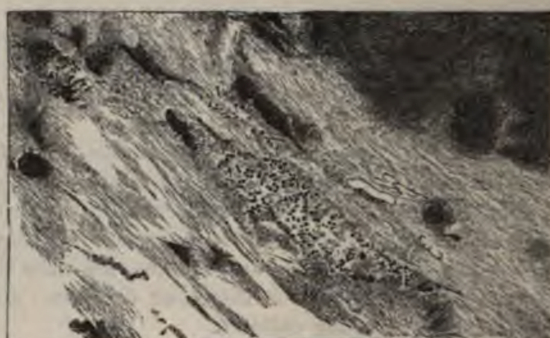


Fig. 343.—Streptococci in the lymph-spaces of the skin from a case of cutaneous erysipelas. The dark patch in the upper right hand corner is the deeper layer of the epidermis. (From a photograph by Koch.)

chains (see p. 244). The zone in which they can be recognized easily is very narrow, as they are soon hidden by numerous migrating leucocytes which fill the spaces of the fibrous tissue, and accumulate round the vessels and in the lymph-spaces. No micrococci can be found when the rash is receding, nor in those parts over which it has passed. The theory of the disease founded on these observations is that the micro-organisms invade the healthy tissues, and by their presence or by the chemical products of their growth, excite inflammation with migration of the colourless corpuscles. The organisms are then destroyed by the migrated corpuscles, and thus are present only in the advancing margin.

Two views have been held concerning the essential nature of cutaneous erysipelas. First, that it is a general specific disease, of which the rash is merely a local manifestation, the wound serving merely as the determining point at which the eruption shall appear; and, secondly, that it is a local infective inflammation and that the fever and other constitutional symptoms are entirely secondary. The arguments in favour of the first view are briefly as follows:—1. Like other acute specific diseases it occurs in epidemics. 2. In

some cases the fever distinctly precedes the appearance of the rash, sometimes by as much as 48 hours. Moreover, I have seen a constitutional disturbance of the same type as that accompanying the local inflammation occur without any such complication. This I had special occasion to observe in a very fatal outbreak of erysipelas that took place in one of my wards in 1851. On that occasion, all the cases in which the cutaneous form of erysipelas appeared were marked by severe constitutional disturbance, attended with much gastro-intestinal irritation. But precisely the same type of general febrile symptoms occurred in patients in the same ward in whom no local manifestation of the disease took place. 3. The severe constitutional disturbance accompanying the disease is often apparently out of proportion to the local mischief. 4. In many cases the disease seems to break out without any breach of surface at which inoculation could have occurred. In some cases it has been known to commence at the edge of a carbolic acid dressing, and not at the wound. 5. As is the case with other acute specific diseases, an attack confers a temporary immunity from the disease; and 6. The fact of its inoculability is no argument against the theory that it is a general disease, for we see the same in small-pox and syphilis. In favour of the local theory the following facts are urged :—1. Local diseases as well as general occur in an epidemic form. 2. When the fever appears to precede the eruption careful observation will always show some local disturbance; either the wound has become red and dry or the lymphatic glands nearest it are tender and swollen. When gastro-intestinal disturbance occurs in many patients in a ward, some of whom develop erysipelas while others do not, the disordered health is not due to the specific virus but to some unhealthy state of the ward which may act as a predisposing cause of erysipelas. 3. The fever continues as long as the rash is extending, and ceases at once when its progress is arrested. In inoculation erysipelas in the rabbit's ear, all constitutional symptoms disappear at once if the ear is amputated. 4. The breach of surface necessary for inoculation is merely microscopic, and consequently it is impossible ever to say with certainty that none existed. Slight excoriations of the skin are very common at the edge of antiseptic dressings, and may readily serve as points of inoculation. 5. Temporary immunity against a second attack is believed to be conferred in other diseases which are primarily local, as in some forms of dissection-wound. The immunity in erysipelas is of very short duration, and patients are frequently met with who are liable to repeated attacks of the disease. 6. Erysipelas differs from acute specific diseases in having no appreciable period of inoculation, and no definite course or duration. 7. Lastly, the characteristic organism has not been demonstrated in the blood or cultivated from it either in animals or in man.

The balance of evidence is therefore in favour of the local theory of the disease, and although it cannot be denied that the virus, through not multiplying in the blood, may possibly, under exceptional circumstances, enter from the lungs or alimentary canal, and be carried to the wound by the blood, yet this is not the rule, and we may hope to prevent the occurrence of this most serious complication of wounds by means calculated to protect the raw surface from the virus.

Diagnosis.—The diagnosis of cutaneous erysipelas is generally easy. From the *exanthemata*, it is distinguished by the character of the eruption; by the way in which it spreads from a single spot, usually a wound or raw surface;

and especially by the characteristic sharply defined margin. It is most commonly confounded with the red blush surrounding a wound in which septic matter is pent up: in this, however, the margin of the redness is not sharply defined; the enlargement of the lymphatic glands and the definite invasion are usually absent. From *inflammation of the veins or of the lymphatics*, the diagnosis is not always easy, more especially as the two conditions frequently co-exist. If a vein is inflamed, the general absence of cutaneous redness, the existence of a hard round cord, and the tenderness along the course of the vessel, are sufficient to establish the diagnosis. In inflammation of the lymphatic vessels the redness is not uniform, but consists of a number of small and separate red streaks, running in the direction of the lymphatics, and affecting the glands towards which they course. These two affections—erysipelas of the skin and inflammation of the lymphatics—are so frequently conjoined that a differential diagnosis is not of much importance.

PROGNOSIS.—The prognosis in uncomplicated cutaneous erysipelas is by no means grave. Of 36 cases of idiopathic erysipelas admitted under the care of the physicians in University College Hospital during a period of ten years, only two died, and one of these was suffering from chronic Bright's disease. When traumatic the disease is far more dangerous. Of 148 cases admitted under the Surgeons or breaking out in the surgical wards during a similar period 35 died. In only five is no special complication mentioned in the report, and one of these was an infant. Two died of pneumonia, seven of pyæmia which attacked the patient after the erysipelas had subsided, two of meningitis from injury to the head; two suffered from Bright's disease, two from severe constitutional syphilis, one from general albumenoid degeneration, two from advanced cancer of the breast, one from cancer of the liver, one from heart disease, two from suppuration of the kidneys secondary to cystitis; one had a large cavity in the lung; one was an habitual drunkard, one was in very bad health, and one was dying at the time of invasion; one died from bed-sores, one from secondary hæmorrhage, one from an abscess, and one from thrombosis of the veins of the leg and sloughing of the skin after the specific disease had subsided. These statistics show that cutaneous erysipelas rarely proves fatal unless it attacks an individual previously suffering from grave constitutional disease, but that by exhausting the strength it may leave the patient liable to fall a victim to other complications of wounds such as pyæmia. Disease of the kidneys is always a most serious complication. High fever, violent delirium, profuse diarrhœa and early prostration are grave signs during the progress of the case. Traumatic erysipelas is more dangerous than idiopathic, as other unhealthy processes are apt to follow in the wound; on the other hand, sores which have been making no progress for a long time often heal rapidly after an attack of cutaneous erysipelas. The disease is most dangerous at the extremes of life.

TREATMENT.—**Preventive Measures.**—The occurrence of erysipelas is best guarded against by attention to hygienic measures, more particularly proper ventilation with pure air, and the avoidance of overcrowding of patients. With every care, however, erysipelas can never be completely eradicated from surgical wards, as it is often epidemic, and brought into the hospital from without. It often happens that erysipelas is unusually frequent in certain wards and even in certain beds. Its persistence in these respects will be found to be owing to some local cause, such as the emanations from a drain or dust-

bin, on the removal of which the disease will cease. Scrupulous attention to cleanliness on the part of nurses and dressers should also be enforced, and the latter should not be allowed to go straight from the dead-house to the ward without previously washing their hands in some disinfectant or antiseptic solution. When erysipelas has already occurred, its further spread may be prevented by isolating the affected patients, and at once taking active measures to purify the ward from which they have been removed.

The **Curative Treatment** of cutaneous erysipelas must always be conducted with reference to the depressing character of the disease. The apparent intensity of the local inflammation in some cases must not lead the Surgeon into the fatal error of employing any so-called antiphlogistic treatment. The treatment required is essentially of a tonic and stimulating character. The principal medicinal remedies consist of bark, quinine, iron, and ammonia. If there be much thirst, these remedies may be given in an effervescent form; but in any case they should be administered in frequent doses. If medicines are not well borne, the stomach rejecting them, I have seen the best possible results follow the free administration of the brandy-and-egg mixture. During the progress of the disease, simple purgatives must be given from time to time. Tincture of the perchloride of iron, originally recommended by Hamilton Bell in small and repeated doses, is now often given in large doses, forty minims every four hours, as recommended by Russell Reynolds and others. It is supposed to exert a specific influence on the disease, and is certainly useful.

The *Local Treatment* is of equal importance with the constitutional. Innumerable modes of treatment have been recommended by different Surgeons, but all are agreed that the first essential is to keep the inflamed part warm. Cold lotions should never under any circumstances be employed; they lessen the vitality of the tissues, and may thus cause local sloughing. In slight cases the part should be covered with flour or starch powder dusted over it, and wrapped in cotton-wool. In the more severe forms, warm applications assiduously continued, especially hot boric acid fomentations applied by means of flannels or spongio-piline, afford the greatest possible relief. The surface may at the same time be covered with a paint composed of equal parts of glycerine and extract of belladonna. I have seen astringent applications, such as a strong solution of nitrate of silver, extensively employed in former years, but not with any very marked success. At University College Hospital the treatment recommended by Valette of Lyons has been tried with very good results. A 30 per cent. solution of perchloride of iron is prepared; forty minims of this solution may be given internally with a little syrup or glycerine and water every two or three hours, and externally the pure solution is applied to the inflamed area. This must be done thoroughly, the solution being rubbed in with a piece of lint or cotton-wool. If necessary the grease must be removed from the surface of the skin by washing with soap and warm water before the lotion is applied. The application is repeated twice a day as long as it is necessary. Wölfler has recommended a mechanical treatment, which consists in applying firm pressure with strapping around the edge of the eruption. This is supposed to prevent its spread by the compression of the lymph spaces. Koch found the following salve useful in ten cases: Creolin one part, iodoform 4 parts, lanolin 10 parts.

The local abstraction of blood and serum from the inflamed part, by the

plan introduced by Dobson, of rapidly making a large number of small punctures, from a quarter to half an inch deep, with the point of a lancet, is of great value when the tension and swelling are extreme; a hot fomentation should be laid over the punctures. Kraske has recently employed scarification of the spreading edge. If the disease have attacked one of the limbs, the application of a bandage is occasionally necessary after the disappearance of the erysipelas, in order to remove the œdema that remains.

2. Cellulo-Cutaneous or Phlegmonous Erysipelas differs from cutaneous erysipelas in so many respects, that it is best regarded as an entirely distinct affection. It was described by Dupuytren under the name of "diffuse phlegmon." It has been said to occur occasionally in an epidemic form. It rarely occurs in its worst form, except in persons who have been addicted to excessive drinking, or who are suffering from chronic renal disease. Locally, it differs from cutaneous erysipelas in the intensity of the inflammation, which is such that it invariably terminates, if left to itself, in diffuse suppuration and sloughing. In depth it always extends to the subcutaneous areolar tissue, and, though generally bounded by the underlying fasciæ, it not unfrequently implicates these, and extends to the intermuscular areolar planes, the sheaths of the tendons, and other deep structures. There is no defined margin to the superficial redness, and the lymphatic glands are frequently unaffected.

Symptoms.—The inflammation may start from a wound or abrasion at an early period after its infliction, but frequently no such cause can be recognized. It is ushered in by the ordinary symptoms of inflammatory fever, accompanied or followed by the signs of severe inflammation in the part affected. The redness is uniform, of a deep scarlet hue, and although somewhat distinctly bounded, is not limited by a sharply defined line: the pain is at first burning, though it may quickly assume a throbbing character; the swelling, at first soft, diffused, and pitting distinctly, soon increases, and becomes tense and brawny, the skin being evidently stretched to its full extent, and the part appearing to be perhaps twice its natural size. Large vesications or blebs containing sero-purulent fluid, sometimes blood-stained, appear in many cases. This condition usually continues up to the sixth or eighth day after the invasion of the disease, during the whole of which time the constitutional symptoms have presented the ordinary type of sthenic inflammatory fever; about this time, however, a change commonly takes place, either for the better or for the worse. If, under the influence of proper treatment, and in a tolerably healthy constitution, the inflammation subside, resolution takes place, with a gradual abatement of all the symptoms. If, however, as usually happens, the disease runs on to more or less sloughing or suppuration of the part, no increase of the swelling, pain, or redness takes place, but on the contrary, some diminution of these signs may occur, and thus give rise to a deceptive appearance of amendment. The skin becomes darkly congested, and the part, instead of being tense and brawny, has a somewhat loose, soft, and boggy feel, communicating a semi-fluctuating, doughy sensation to the fingers. This change from a tense brawny state to a semi-pulpy condition indicates the formation of pus and slough beneath the integument. The pus can be detected only by careful palpation; hence the Surgeon must daily examine the state of the part, and neither trust to the reports of others, nor to the general appearance of the diseased structures, for a knowledge of the probable condition of the subjacent tissues. If an

incision be now made, the areolar tissue will be found loaded with an opalescent semi-fluid exudation, distending its lymph-spaces but not flowing from the wound; the retention of this fluid gives a gelatinous appearance to the sides of the incision. If the alteration in structure have advanced to a stage beyond this, the areolar tissue will be found to have been converted into dense masses of slough, bathed in thin ichorous pus; these sloughs have not inaptly been compared in appearance to masses of decomposed tow, or wet chamois leather. Whilst these changes are going on below the surface, the skin becomes dusky, and assumes a marbled appearance, rapidly changing into black sloughs, and being undermined by large quantities of broken-up areolar tissue and of ill-conditioned pus, without any appearance of pointing, however extensive the subcutaneous mischief may be. These destructive changes expose muscles, fasciæ, and blood-vessels, and may induce necrosis of the bone, or suppuration of the joints. They occur most readily in those parts of the body that possess the lowest degree of vitality, and hence are more common in the legs than in the scalp. As soon as the skin gives way, unless some means be taken to prevent it, the sloughs undergo ordinary offensive putrefaction, and the products of this process cause local aggravation of the inflammation and the constitutional symptoms of septic poisoning. If the patient recover, there will be a tedious cicatrization of the deep cavities that are left; or considerable œdema, often of a solid character—a kind of false hypertrophy of the part—which may continue for some considerable time. In other cases, there may be such extensive local destruction of the soft tissues, with exposure and death of the bones or suppuration of the joints, that amputation of the limb may be required to save the patient's life. No operation of this kind, however, should ever be practised for phlegmonous erysipelas, unless the disease be strictly localized, and show no further tendency to spread; nor until the fever has subsided, except such as is of a hectic character and dependent on the septic suppuration.

During the progress of these local changes, the *Constitutional Symptoms* undergo corresponding modifications. At first of an active inflammatory character, the fever, when suppuration and sloughing have set in, often suddenly becomes asthenic. Although in some cases there is at first no diminution in the severity of the symptoms, the constitution gradually gives way after the patient has struggled for a few days against the exhausting influences of the disease, and death speedily supervenes. If the patient survive the stage of sloughing, pyæmia, septicæmia or hectic from profuse discharge may carry him off. If recovery eventually take place, it may be with a constitution impaired and shattered for years. The immediate danger is always greatest when the head is affected. The remote danger from the effects of suppuration of areolar tissue, necrosis of bones, and inflammation of the joints, is greatest when the lower extremities are the seat of the disease.

A variety of the cellulo-cutaneous erysipelas has been described as **Œdematous Erysipelas.** By this is meant not merely the effusion into the areolar tissue which occurs in all the varieties of the disease, but a peculiar form, specially marked by œdema of the areolar tissue, with less inflammation of the skin than usual. There is great swelling, which pits deeply on pressure, with little pain or tension, and but moderate redness of the skin; the constitutional symptoms are less marked than in the other varieties of the disease; it

is principally met with in old people, or in persons of a dropsical tendency, in whom it occurs especially about the legs, scrotum, or labia, sometimes giving rise to permanent and solid enlargement.

Diagnosis.—Phlegmonous erysipelas is easily recognized by the characteristic symptoms just described, when arising from some slight superficial injury or spontaneously; but if it should happen to complicate a deep wound or compound fracture, it is easily confounded with *simple septic inflammation* consequent upon pent-up decomposing discharges or blood. In all probability a very large proportion of the cases formerly described under the name of erysipelas were in reality simple septic inflammations not of a specific character. The so-called phlegmonous erysipelas of the scalp following a wound is, for example, almost invariably the result of the burrowing of putrid discharges beneath the pericranial aponeurosis.

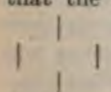
From *spreading gangrene* it is distinguished by its slower progress and the absence of fœtid gases in the sloughs before the skin gives way.

Prognosis.—The prognosis in phlegmonous erysipelas is always grave. Of twenty-four cases admitted into University College Hospital seven died. It is especially dangerous if it affect the head or parts in which the areolar tissue is abundant and lax, as the scrotum or orbit. Much also will depend upon the promptness with which efficient treatment is begun and the means adopted to prevent septic poisoning from putrefaction of the sloughs. The disease is most dangerous at either of the *extremes of life*. If the *constitution* be sound, very extensive mischief may be recovered from; if, on the other hand, it be depressed or broken by want of the necessaries of life, by fatigue, over-exertion, or indulgence in stimulants, a very slight amount of disease may prove fatal. The most dangerous complication, and one which when it exists almost precludes the hope of recovery, is *chronic disease of the kidneys*, either in the form of the granular contracted, or of the large white, kidney. I have never seen any patient labouring under these diseases, and attacked with phlegmonous erysipelas, escape with life; the sloughing and suppuration running on unchecked by any treatment that could be adopted.

Pathology.—The disease is a local infective process caused by the presence of the streptococcus pyogenes (p. 244), which is found in the whole affected area and not merely at the advancing margin. The first effect is an abundant coagulable exudation which distends the lymph-spaces to the greatest possible extent. Unless relieved by treatment, the exudation softens, migration continues and the spaces become filled with pus; then partly as the result of the pressure of the exudation, and partly from the direct irritation of the acrid chemical products of the process, the whole affected connective tissue perishes. The inflammation is believed to be caused by the irritating products to which the micro-organisms give rise in the fluids of the part by a process analogous to fermentation. These products soak into the surrounding lymph-spaces and excite further exudation in which the organisms spread. By incisions into the part the exudation is drained away instead of soaking into the surrounding parts, and thus the spread of the organisms is checked, while at the same time tension being relieved one great source of irritation is removed, and the tissues may thus escape death. The viscera present nothing special. There will be the signs of septicæmia (see Septicæmia), or pyæmia (see Pyæmia), should either of these affections have been the immediate cause of death.

Treatment.—In the early stage, our object is to prevent the inflammation from running into gangrene of the affected tissue. The fever being at this period commonly sthenic, the administration of purgatives, or effervescent salines may give relief, but blood-letting is never required: and depressing remedies, such as salines, must be given with great caution. Tonics and stimulants require to be given early and late. As the disease advances, and symptoms of depression come on, a more stimulating plan of treatment must be adopted. As the pulse becomes feebler, and the tongue browner, ammonia, bark, and especially port wine, and the brandy-and-egg mixture, must be administered. In the more advanced stages of the disease our sole object must be by nourishing diet, and the use of stimulants and tonics, to carry the patient through the depression.

Local Treatment.—The part affected must be kept at rest, and elevated, if it be a limb; it must be well painted with equal parts of glycerine and extract of belladonna, and have hot fomentations assiduously applied, cold being even more prejudicial here than in cutaneous erysipelas; in this way, the swelling and tension may perhaps be removed, and sloughing of the areolar tissue prevented. In the majority of cases, however, incisions must be made into the part for the relief of tension. This mode of practice is the most effectual means we possess for the *prevention* of sloughing; hence the incisions should be made early, before there has been time for the tissues to lose their vitality. As soon, indeed, as the skin becomes brawny, indurated, and tense, incisions will afford the greatest possible relief, reducing the tension by the gaping, and the swelling by the exit they afford to the inflammatory exudation. Some Surgeons have recommended that one long cut should be made through the inflamed structures; so considerable a wound, however, not only inflicts a serious shock on the system, but the loss of blood from it may be so great as to be fatal; moreover, a single long incision does not relieve tension so effectually as a number of smaller ones. These preventive incisions should therefore be from two to three inches in length; at most they should not extend deeper than into the gelatinous-looking subcutaneous areolar tissue, unless it happen that the disease has extended beneath the fascia, when they may be carried



through it also. The incisions should be so arranged in fours, as to enclose a diamond-shaped space, as in this way the greatest relief is given to the tension of the part. As it is desirable that as little blood as possible be lost, hæmorrhage may be prevented by elevating the limb and applying a tourniquet before using the knife, but it is better not to employ Esmarch's bandage, for fear of driving the unhealthy inflammatory products into the circulation. In those cases in which the disease is not already complicated with an open wound and decomposing discharges, great advantage will be derived from the employment of antiseptic precautions, thus preventing putrefaction of the effused inflammatory fluids which fill up the spaces of the areolar tissue exposed by the incisions. Before making the incisions, the limb should be well fomented for a quarter of an hour with cloths wetted with a hot solution of carbolic acid (1 in 30). The tourniquet is then applied, and the incisions made with antiseptic precautions. To arrest excessive bleeding, the wounds must be plugged with iodoform or salicylic wool or some other antiseptic material. The treatment may then be carried out with the carbolic gauze or some other efficient antiseptic dressing, such as hot salicylic wool poultices, iodoform wool or

fomentations of boric lint. If suppuration and sloughing have taken place, as indicated by a boggy feel of the parts, free incisions should immediately be made in order to let out pus and sloughs. After this, the skin will often be found to be greatly undermined, blue, and thin, with matter bagging in the more dependent parts; if so, egress must be made for it by free counter-openings, and drainage-tubes inserted if required. During the after-treatment, frequent dressing is necessary to prevent an accumulation of pus, and the sloughs must be removed as they separate. Care should be taken not to destroy any of the vascular connections of the skin with adjacent parts; but, in order to get proper cicatrization, it will often be found necessary to lay open sinuses, or to divide bridges of unhealthy and blue integument stretching across chasms left by the removal of the gangrenous areolar tissue. If the loss of substance be great, the cicatrix that forms may be weak, imperfect, or so contracted as to occasion great deformity of the limb. In other cases, again, the diseased state of the bones and joints may be such as ultimately to call for amputation, either in consequence of the local deformity and annoyance, or in order to free the constitution from a source of hectic and irritation. In all circumstances, the patient's health will usually continue in a feeble and shattered state for a considerable time after recovery, requiring change of air, great attention to habits of life and a nourishing diet.

3. CELLULAR ERYSIPELAS, or as it is more often termed **Diffuse Inflammation of the Cellular Tissue** or **Cellulitis**, is an acute local infective process originating in the inoculation of a virus either in a wound or by a small puncture or scratch. Diffuse cellulitis may arise as a consequence of ordinary injuries, but it is especially apt to follow those in which there has been any inoculation of animal poisons, as from dissection-wounds, the stings of insects, and the bites of venomous reptiles. The diversity of its origin, however, and the different course assumed by different cases would lead us to suppose that the virus in cellulitis is not always necessarily the same. The disease resembles erysipelas in the diffuse character of the inflammation, and it arises under circumstances similar to those in which erysipelas is observed to originate. In some cases the constitutional symptoms present nothing peculiar, being merely those of acute inflammatory fever; in others, especially those arising from the inoculation of the poison of a dead body, the phenomena may be those of acute septicæmia. The term "cellular erysipelas" or "diffuse cellulitis" must, therefore, be regarded as a clinical expression for an acute infective inflammation, spreading by the lymphatics and lymph-spaces of the areolar tissue, and not as implying a definite specific disease, such as simple cutaneous erysipelas undoubtedly is.

Local Signs.—The local signs will vary with the part affected. If it is the subcutaneous tissue of a limb, great swelling, tension and pain are present, and the part feels brawny in some parts, œdematous in others. The skin is slightly reddened in patches, has a mottled appearance, and may in extreme cases follow the same course as phlegmonous erysipelas, running into blackish sloughs. This form in fact differs from phlegmonous erysipelas only in the affection of the skin being entirely secondary to that of the subcutaneous tissue. The extent to which the disease may spread varies greatly; when once it has set in, it frequently runs rapidly up the whole limb, extending also to the sides of the trunk.

In other cases, especially in the form that follows dissection-wounds, the

inflammation at the seat of inoculation may be slight, the mischief being chiefly at a distance; thus in a punctured wound of the finger, the diffuse inflammation may take place principally in the planes of areolar tissue in the axilla and sides of the chest. Diffuse cellulitis also affects the internal planes of areolar tissue. This may happen, for instance, in the fasciæ of the pelvis after lithotomy, or in the anterior mediastinum after operations at the root of the neck. In these cases there is deep-seated pain and tenderness, and the skin may be slightly reddened and œdematous. The superficial veins are often full and clearly indicated on the surface. Sloughing frequently occurs with remarkable rapidity, the areolar tissue being broken down into pus and shreddy sloughs in the course of thirty-six or forty-eight hours, more especially when the disease has resulted from the inoculation of decomposing animal matter.

The **constitutional symptoms** vary in different cases. In some they are those of acute inflammatory fever; in others the affection is accompanied by signs of the gravest blood-poisoning. In these latter there is probably a general infection of the system. After the sloughs become exposed to the air decomposition rapidly sets in, and the symptoms then assume the type of acute septic poisoning from the absorption of the chemical products of putrefaction.

Pathological Anatomy.—The state of the areolar tissue is the same as in phlegmonous erysipelas. The streptococcus pyogenes is usually found in the inflammatory exudations. Should the patient die, the viscera present the ordinary appearances of acute blood-poisoning (see Septicæmia).

Prognosis.—If the subcutaneous tissue of a limb only is affected many cases can be saved by proper treatment. Amongst twenty-four cases registered as cellulitis in the reports of University College Hospital there were six deaths. When the deeper planes of areolar tissue are affected, and when the process is very acute, death commonly occurs early, often in two or three days; in other instances life may be prolonged for some weeks, the patient ultimately dying of exhaustion or of some secondary complication, as pyæmia.

Diagnosis.—Superficial cellulitis closely resembles cellulo-cutaneous erysipelas, and in the later stages it may be indistinguishable when the skin becomes affected. In any case the diagnosis is of little importance as the treatment is the same. Deep-seated cellulitis is often very difficult to recognize; the swelling, with some œdema and slight redness, the fulness of the superficial veins, and the deep-seated pain and tenderness, with the history of a cause likely to induce the disease, such as a *post-mortem* wound, combined with the characteristic constitutional condition, will, however, usually enable the Surgeon to recognize the condition.

Treatment.—In the treatment of diffuse cellulitis it is usually necessary to administer stimulants early; ammonia, wine, or brandy may be required from the very first. The Surgeon must judge of this by the constitutional condition of the patient, and more particularly by the state of his pulse and tongue. The *Local Treatment* is precisely of the same kind as that adopted in phlegmonous erysipelas, except that the incisions require to be made earlier and perhaps more freely; in all other respects, there is no difference between the general management of these two forms of disease.

SPECIAL FORMS OF EXTERNAL ERYSIPELATOUS INFLAMMATION.—**Erysi-**

pelas of Newly-born Infants, Erysipelas Neonatorum, is occasionally met with, more particularly in lying-in hospitals, or in situations where the mother and child are exposed to depressing causes of disease. It usually appears a few days after the birth, at first about the abdomen and genitals, and soon spreads widely over the body, being characterised by a dusky redness which rapidly runs into gangrene of the affected tissues. It starts in many cases from the raw surface left by the separation of the umbilical cord. It is extremely fatal, owing to the feeble vitality of the child, and presents but few points for treatment; change of air and of nursing, with the administration of a few drops of spirits of ammonia or brandy from time to time, being all that can be done.

Idiopathic Erysipelas of the Head is always of the cutaneous form, having no tendency to end in suppuration or gangrene. The only peculiarity it presents is the excessive œdema of the subcutaneous tissue usually accompanying it, which completely obliterates the features. As the result of the tension caused by this, a little pus may occasionally form in the eyelids. Large blebs on the skin are very common. It is always accompanied by some redness and soreness of the throat. The inflammation as a rule starts from the junction of the mucous membrane and skin, as at the angle of the eye, spreading quickly to the bridge of the nose; at the orifice of the meatus auditorius externus, or the angle of the mouth. Its origin without a small abrasion or wound has frequently been denied. The course, symptoms, prognosis and treatment are those of simple cutaneous erysipelas (pp. 944 *et seq.*).

Cellulitis of the Orbit may occur primarily, or as the result of extension of the disease from the neighbouring structures. It is dangerous, and often fatal from thrombosis of the cavernous sinus and meningitis. It commences with a violent deep-seated pain in the orbit; the conjunctiva becomes injected and ecchymosed, the eyelids are greatly swollen, red, and œdematous; the eyeball protrudes, and vision is impaired or altogether lost. Symptoms of cerebral inflammation may now set in, the patient becoming delirious and finally comatose.

The *Treatment* consists in fomentations, with early and free incisions into the orbit, made by pushing a lancet flat-wise between the eye-ball and the orbital walls, through the inflamed conjunctiva, the eyelids having previously been everted. In this way inflammatory effusions and pus may be evacuated, and the eye saved. Destructive abscesses of the orbit occasionally occur in the puerperal state, requiring, when practicable, the free evacuation of pus, in the way just mentioned.

Diffuse Cellulitis of the Scalp following a wound has already been described (pp. 717, 720).

Diffuse Cellulitis of the Submaxillary Region was first accurately recognized by Ludwig, of Stuttgart, in 1836; hence the affection has sometimes received the name of Ludwig's Angina. It has also been specially described by Bickersteth, of Liverpool, and by Croly, of Dublin, and in an exhaustive paper by R. W. Parker (*Lancet*, Vol. II., 1879). Submaxillary cellulitis is an acute diffuse inflammation of the areolar tissue beneath the deep cervical fascia, attended with the ordinary severe constitutional symptoms of diffuse cellulitis, and terminating rapidly in suppuration, with sloughing of the affected tissues unless relieved by prompt and efficient treatment. The peculiar danger of the affection depends on the importance of the parts affected

and on the density of the cervical fascia, beneath which the inflammatory products are pent up at a high degree of tension. The disease may commence without evident cause after exposure to cold, and is said occasionally to have appeared in an epidemic form; it may arise also from extension from the lymphatic glands in scarlet fever, or may follow wounds or other injuries. In other cases it is connected with a diseased tooth, most commonly with a necrosed fang. It may occur at any age; in adults, according to Furneaux Jordan, it most frequently occurs in those addicted to excessive drinking. It commences as a brawny inflammatory swelling at the fore part of the neck, or near the angle of the jaw, surrounding the submaxillary gland, or more rarely the parotid. It rapidly spreads towards the chin, extending to the opposite side, and afterwards down the neck over the larynx. The tongue is pushed upwards, and the hardened tissue can be felt in the floor of the mouth on each side of it; the movements of the jaw are interfered with, and deglutition becomes difficult. Sometimes there is great swelling of the tongue from pressure on the lingual veins. When gangrene of the areolar tissue sets in, the swelling softens and becomes boggy; the mucous membrane may give way, and a foul discharge may come from the mouth. If unrelieved by treatment it is extremely fatal; death may occur from blood-poisoning or from suffocation, the disease spreading to the root of the epiglottis, and producing œdema glottidis.

The *Treatment* consists in making a free incision in the mesial line, from the chin to the os hyoides, through the infiltrated parts, from which, if it be made sufficiently early, a thin dark serum, but no pus will be seen to exude. The incision must be carried to a depth of two inches or more towards the base of the tongue, keeping carefully to the middle line, until the whole of the brawny infiltration has been divided. If the swelling has commenced at one side and has not reached the middle line, whenever it is possible the incision should still be kept in the same situation, as lateral incisions are accompanied by great danger of hæmorrhage which it would be very difficult to arrest. If the condition be connected with a diseased tooth, a small cavity will often be found at a considerable depth, containing horribly fœtid matter, and at the bottom of this, bare bone may be felt on the inner aspect of the jaw. In spite of this, recovery usually occurs without the separation of dead bone.

Erysipelas of the Scrotum—the "inflammatory œdema" so well described by Liston—is of frequent occurrence, as the result of wounds, ulcers, and other sources of irritation in this neighbourhood. The scrotum swells to a large size, being uniformly red, but with a semi-transparent glossy appearance, pitting readily on pressure, and feeling somewhat soft and doughy between the fingers; the integuments of the penis are also greatly swollen and œdematous, and sometimes the inflammation extends to the areolar tissue of the cord. The chief characteristic of this form of erysipelas is its tendency to run into slough without any previous brawny or tense condition of the parts; the dartos becoming so distended with the inflammatory exudation that the circulation through it is arrested. When an incision is made into it in this state it scarcely bleeds, and the sides of the wound present a yellowish-white gelatinous appearance.

The *Treatment* consists in making a free incision about four inches in length on each side of the septum, taking care not to go so deeply as to wound the testes; the part must then be supported on a pillow, and well fomented. If this incision be not made at once, a great part or even the

whole of the scrotum may slough away, leaving the testes and cords bare; in these unpleasant circumstances, however, the parts will often with great rapidity become covered with new integument. The œdema of the penis usually subsides of itself, or after making a few punctures in it; should its integuments, however, threaten to slough, a free incision must be made into it, or the prepuce must be slit up.

Erysipelas of the Pudenda is occasionally met with in ill-fed unhealthy children in whom cleanliness is neglected. The parts become dusky red, swell considerably, and quickly run into gangrene, which spreads up the abdomen or down the nates. It may prove fatal by inducing peritonitis or exhaustion. In the *Treatment*, ammonia, bark, and chlorate of potash, with good nourishment, and a little wine, are the principal means, at the same time that the parts are bathed in a warm antiseptic solution and well fomented.

Diffuse Cellulitis of the Ischio-Rectal Fossa is not uncommon in old and feeble subjects, as the result of exposure to cold. The symptoms are those of cellulitis in general, a brawny hard swelling by the side of the rectum, with redness of the skin, and great pain and tenderness. The fat of the ischio-rectal fossa rapidly sloughs, and a foul, fœtid abscess, the pus of which is mixed with shreds of gangrenous tissue, rapidly forms. The *Treatment* consists of free and early incisions. At a later stage it may be necessary to divide the sphincter before the cavity will heal.

INTERNAL ERYSIPELATOUS INFLAMMATIONS.

By **Internal Erysipelas** we mean those forms of diffuse inflammation which affect the Mucous or Serous Surfaces.

ERYSIPELAS OF MUCOUS SURFACES.—The mucous tract that is chiefly affected by this disease is that covering the fauces, the pharynx, and the larynx.

Erysipelas of the Fauces may be due to extension of the disease from the head and face to these parts; or it may commence as a primary affection, occurring perhaps at the same time that the rash appears on the cutaneous surface of some distant part of the body. When the fauces are erysipelatous, they present a bright crimson or scarlet colour, with some swelling and thickening of the soft palate and uvula; the patient also most commonly has huskiness or complete loss of voice, and occasionally some croupy symptoms. The glands at the angle of the jaw are always swollen and tender. At the same time there is a good deal of febrile disturbance, with a pungent hot skin and quick pulse. This form of erysipelas is peculiarly contagious, and occurs not unfrequently in the attendants of those who are labouring under some of the other varieties of the disease; of this I have seen numerous instances. In many cases, also, it is epidemic, spreading through a house and affecting almost every inmate.

Treatment.—The best results are obtained by sponging the inflamed parts freely with a strong solution of the nitrate of silver; and, if there be much constitutional depression, by administering full doses of ammonia, with camphor or bark. Should the disease go on to sloughing (which not unfrequently happens), constituting one of the forms of "putrid sore throat," the mineral acids and bark, with chlorinated gargles, and the brandy-and-egg mixture for support, will be found most useful. In many cases, this disease ...ues limited to the palate and fauces; but in others it extends upwards

or downwards. It may extend upwards through the nares, out through the nostrils, and thus spread over the face and head, or downwards, implicating the larynx.

Erysipelatous Laryngitis is extremely dangerous. The inflammation, commencing in the fauces, rapidly spreads to the mucous membrane and loose submucous areolar tissue external to and within the larynx, giving rise to extensive œdematous infiltration, which, by obstructing the rima glottidis, may readily suffocate the patient. In consequence of this special tendency to œdema, the disease has by many writers been termed "*œdematous laryngitis.*" After death, the submucous areolar tissue of the fauces, that about the base of the epiglottis, and especially that which enters into the arytæno-epiglottidean folds and that covering the posterior part of the larynx, will be found to be distended with serum or a sero-puriform fluid. This infiltration reaches to the rima of the glottis, and, extending into the interior of the larynx, gives rise to such swelling that its cavity is nearly obliterated. Great as the swelling may be in all these parts, however, it never spreads below the true vocal cords. This fact, which is very important, is explained by the mucous membrane being adherent to the fibrous tissue of which these structures are composed, without the intervention of any submucous areolar tissue. The progress of this œdematous inflammation of the mucous membrane and loose submucous tissue in these situations, is often amazingly rapid, the swelling being sufficient to induce suffocation at the end of thirty-six or forty-eight hours or even sooner. If the patient be not carried off in this way, there will be a great tendency to suppuration and sloughing of the affected tissues, leading perhaps eventually to death from septicæmia or pyæmia.

The *Symptoms* of this affection are strongly marked. Difficulty and pain in deglutition, and huskiness of the voice, are followed by more or less difficulty in breathing, hoarse croupy cough and tenderness under the angles of the jaw and about the larynx. The difficulty in breathing increases, and may speedily threaten the life of the patient, giving rise to fits of intense dyspnœa, in one of which he may probably suddenly die. The difficulty is greater in inspiration than in expiration, as the swollen parts above the opening of the larynx fall together like a valve in the former act, while they are easily separated by air coming from below in the latter. On examining the throat the fauces will be found much reddened and dusky in tint, and by depressing the tongue the epiglottis can be felt, and perhaps seen, to be rigid and erect. Examination with the laryngoscope readily shows the condition of the parts to be as above described. Enlarged lymphatic glands can usually be felt early in the case behind the angle of the lower jaw.

In the *Treatment,* local means are of the first importance. The tongue having been well depressed, the posterior part of the larynx, the epiglottis, and the arytæno-epiglottidean folds must be well scarified by means of a probe-pointed bistoury, protected nearly to its extremity by strapping or lint wrapped round it. If no better instrument be at hand in case of emergency, a very useful amount of scarification may be done by the nail of the Surgeon's index-finger, notched with a knife to make it tear the mucous membrane more readily. The patient should then be directed to inhale the steam of hot water, to which a few drops of creasote or carbolic acid may be added, and several leeches may be applied under each angle of the jaw, to be followed by large and hot poultices. The bowels must be kept well opened; most frequently, I have found antimonials of great service in the early stages, followed later by support and

stimulants. A few hours after the engorged tissues have been unloaded by scarification, the fauces, pharynx and upper part of the larynx should be well sponged out with a strong solution of the nitrate of silver (sixty grains to an ounce), which must be applied freely. If, notwithstanding the employment of these measures, the dyspnœa increase, the face becoming pale, livid, and bedewed with a clammy perspiration, it will be necessary to open the windpipe to save the patient from suffocation. In doing this I prefer laryngotomy, for reasons that will be mentioned when I come to speak of the Diseases of and Operations on the Air-passages. In order, however, that this operation may be successful, it must not be too long delayed, and should not be looked upon as a last resource. If it be done in time (and time in these cases is most precious, owing to the rapid progress of the disease), the patient's life may probably be saved ; but if it be deferred too long, congestion of the lungs will come on, and the patient will sink from slow asphyxia, even though air be at last freely admitted. If the patient survive to the stage of sloughing we must rely upon general support, with gargles of chlorate of potash, and bark.

Erysipelas of the Serous Membranes was formerly supposed to be of common occurrence, all those cases of diffuse inflammation which are now regarded as of septic origin being at one time classed as erysipelatous. It is highly probable that some cases of diffuse meningitis and peritonitis following injuries of the head and abdomen are truly erysipelatous and dependent upon a specific virus ; but in by far the greater proportion of these cases the inflammation is due to the diffusion of decomposing discharges over the surface of the serous membrane.

WHITLOW, PARONYCHIA OR PANARITIUM.

Whitlow or **Paronychia** is a diffuse inflammation of the finger which is, perhaps, most conveniently described in this place as in many cases of essentially the same character as cellulitis. It occasionally occurs in epidemics; the constitutional disturbance attending it is often very severe for an affection apparently so slight, and assumes the same character of speedy depression that we observe in the erysipelatous group of diseases. In many cases, as the inflammation spreads beyond the finger in which it commenced to the back of the hand, it assumes a distinctly erysipelatous character. In others, however, it is evidently not specific, and results from the inoculation of ordinary septic matter, the subsequent effects being dependent on the anatomical structure of the parts affected.

Four forms of whitlow are commonly described :—

1. In **paronychia ungualis** or **Sub-epithelial Whitlow**, the affection is limited to the ungual phalanx of the finger. It commences as the result of a prick or some other slight injury, or from the inoculation of septic matter into a fissure or edge of the nail. At first there is redness, most commonly at one side of the nail, with some swelling and the most acute tenderness. The inflammation soon reaches the stage of suppuration, and a drop of pus is formed raising the epithelium. The thick epithelium of the finger confines the pus which, not being able to escape superficially, burrows more deeply. If it be in close contact with the matrix of the nail it may extend into this. The nail then becomes partly raised by pus from the matrix, and may separate after

long and tedious suppuration. In other cases the pus burrows into the pulp of the finger, and the condition then merges into the second variety to be described immediately.

Treatment.—As soon as the patient complains of acute pain and tenderness, and redness and swelling are evident in the finger, an attempt should be made to find the exact locality of the pus by pressing on the finger with some blunt instrument such as the point of a pencil. If an acutely tender spot be found the finger must be soaked in hot water to soften the cuticle, which must then be carefully shaved away with a very sharp knife. In this way a small drop of pus may often be let out from between the epidermis and the cutis, and the whole trouble nipped in the bud. A little wet boric acid lint may then be applied and the finger soon heals. If it have extended beneath the nail the loosened portion must be cut away with scissors to give a free exit to the pus, or in extreme cases the whole nail must be removed. A little iodoform may be dusted on the surface, and a boric lint dressing applied. The strong lead lotion (p. 216) is often very useful in these cases.

2. **Paronychia Cellulosa** or **Subcutaneous Whitlow** may arise, as above stated, from an extension of the variety just described. In other cases it is caused by punctured wounds of the finger, especially when made with dirty instruments, and occasionally it arises without evident cause. In it the pus is diffused through the fat and areolar tissue forming the pulp of the finger. It runs the ordinary course of cellulitis elsewhere. The ungual phalanx becomes swollen, tense, red, and most acutely tender. The redness may soon extend to the whole finger, red lines of inflamed lymphatics may be seen running up the arm, and the axillary glands may become swollen and tender. If unrelieved by treatment, the pus, being unable to point through the thick cuticle of the finger, especially in the horny hands of working men, becomes diffused through the whole pulp. The areolar tissue sloughs, and as in this situation it is intimately connected with the periosteum of the ungual phalanx, this also perishes and the bone necroses. If still left unrelieved it most commonly raises the cuticle, and finally this gives way and exposes a sloughing opening in the cutis, through which, if a probe be passed, the bare ungual phalanx may be felt. In some cases, before the pus finds exit externally, it may have extended into the sheath of the flexor tendons or the distal joint of the finger.

Treatment.—In this form also an attempt must be made to find the pus early by shaving away the cuticle, as at first it is often very limited in amount and superficial. If this fails and the symptoms are not very acute, the finger must be thickly coated with glycerine and belladonna, and wrapped in a few layers of hot wet lint, over which must be placed some gutta-percha tissue made into a cot by sealing its edges with chloroform. The finger must then be wrapped in cotton-wool and the hand elevated. Under this treatment the inflammation may subside without suppuration. Soaking the hand at intervals in hot water gives great relief. If, in spite of this, the symptoms become more marked, a longitudinal incision must be made in the middle line of the pulp of the finger. It must be remembered that the tense swollen pulp gives a sensation exactly resembling fluctuation, for which it may readily be mistaken. After the pus is evacuated the wound should be treated by some antiseptic dressing, and usually heals quickly.

3. **Paronychia Osseosa** or **Periosteal Whitlow** is a rare form in which the inflammation commences deeply in the pulp in immediate contact with

the periosteum of the phalanx. It is said most commonly to follow severe pinches or contusions of the finger. It is characterised by intense throbbing pain shooting up the arm. The symptoms develop rapidly, with a good deal of constitutional disturbance. The pulp of the finger is very tense, and the redness extends to the other phalanges. The *treatment* consists of a free incision to the bone in the middle line of the pulp. The phalanx will be found bare and already separated from its periosteum.

The *treatment of a necrosed ungual phalanx*, either arising from this form of whitlow or the preceding, consists in removal of the dead bone through the incision in the pulp. The phalanx should never be amputated, as a useful extremity to the finger is always left after removal of the bone.

4. **Paronychia Tendinosa, Thecal Abscess,** or **Suppuration in the Sheaths of the Flexor Tendons,** is a more serious condition than the preceding, and is fraught with danger to the finger or hand. It may arise as the consequence of a punctured wound penetrating the sheath, or by extension from one of the other varieties of whitlow. The whole finger, both back and front, swells considerably, becomes red and tense, with much throbbing and shooting pain. The affected finger is semi-flexed, and any attempt to extend it causes intense pain. The swelling soon extends into the palm at the root of the finger and to the corresponding knuckle on the back of the hand. The swollen palm usually preserves nearly its natural colour, or if soaked in water or poulticed becomes dull white, owing to the great thickness of its cuticle. The most marked redness is usually on the knuckle and at the back of the finger, which may give a false idea as to the situation of the pus. The constitutional disturbance is severe and the temperature considerably elevated.

In this condition, unless prevented by treatment, the pus will extend to the limits of the sheath in which it is contained. The sheaths of the index, middle and ring fingers do not communicate with the common sheath which passes under the annular ligament, but are closed below opposite the heads of the metacarpal bones, and, therefore, in suppuration in these fingers the pus does not extend beyond that point. The sheath of the little finger, on the other hand, always communicates with the general sheath. (Fig. 344.) The sheath of the tendon of the thumb is uncertain: in some cases a special synovial membrane covers the tendon passing under the annular ligament without communicating with the general sheath, in others it joins the common sheath. Thecal abscess in the thumb or little finger is, therefore, far more serious than the same condition in the three middle digits. When the suppuration extends to the common sheath the most prominent symptom which attracts the attention of the patient is the red puffy swelling at the back of the hand. The Surgeon on seeing this will always turn the hand over and examine the palm. This will be found to be tense and tender on pressure. There will be fulness in front of the wrist above the annular ligament, and often some redness. If much pus is present, fluctuation may be felt from the palm to the swelling in the wrist. The fingers are semi-flexed, and any attempt to extend them causes pain, but this is most marked in the thumb and little finger. If an opening exists already in the digital part of the sheath of the thumb or little finger, pressure on the palm will cause pus to flow from it. If an exit be not provided for the pus it may burst through the upper limit of the flexor sheath, and extend between the deep and superficial muscles

of the forearm nearly to the elbow. Owing to the close proximity of the synovial membrane to the interphalangeal articulations and the wrist-joint, it not uncommonly happens that these are opened and destroyed by acute septic arthritis; and thus this condition may necessitate amputation of a finger, or if the common sheath is affected, of the whole hand. Sloughing of the flexor tendons is a very common occurrence in thecal abscess, some inches of the tendon coming away after prolonged suppuration, leaving the finger stiff and useless.

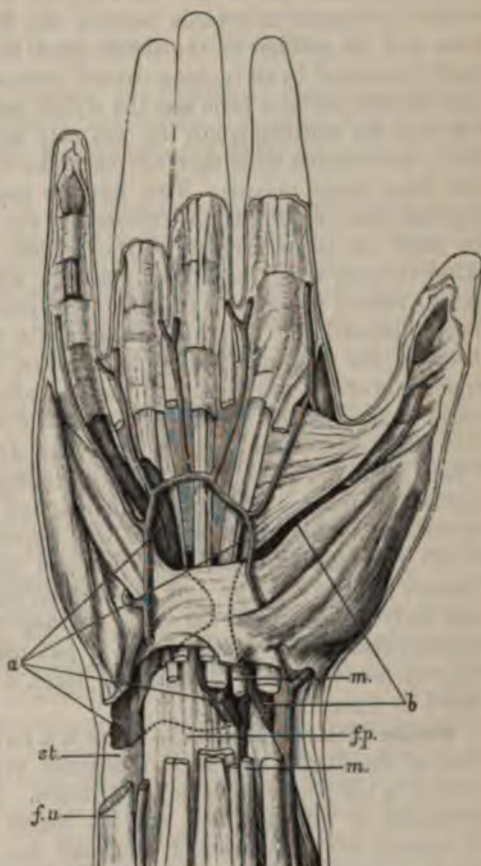


Fig. 344.—Preparation showing the arrangement of the Sheaths of the Flexor Tendons at the Wrist. *a*, Sheath of flexors of fingers; the part which lies in contact with the annular ligament and the upper limit of the part behind the flexor profundus are represented by dotted lines. *b*, Sheath of flexor longus pollicis; the part which lies in contact with the annular ligament is represented by a dotted line; *m*, median nerve; *f.p*, flexor profundus digitorum; *f.u*, flexor carpi ulnaris; *s.t.*, styloid process of ulna.

Treatment.—It is most important in all cases of thecal abscess that the pus should be let out early and by free incisions, in order to avert the complications above mentioned. To do this the patient should be put under an anæsthetic, and the limb rendered bloodless by elevation and the application of a tourniquet. A median incision on the finger, not opposite one of the interphalangeal articulations, is then carefully made towards the affected sheath. It may be that the pus is in close contact with the sheath and not in it; if the limb be bloodless this can usually be recognized, and the complication of opening the synovial membrane avoided. If the swelling extends from the finger to the palm the thecal abscess may be opened, without danger of wounding the palmar arches or any important nerves, by cutting towards the head of a metacarpal bone upon the bone itself and parallel to its axis, so as to avoid the interdigital spaces. Heath and Morrant Baker have especially insisted upon the advantages of this method of opening a thecal abscess and thus avoiding the median incision on the finger. They recommend that incisions on the finger in cases of whitlow should be placed laterally so that a healthy sheath may not be accidentally opened.

If the common sheath is affected it must be opened above the annular ligament at the wrist.

If the little finger has been the starting point of the mischief the incision

whole of the scrotum may slough away, leaving the testes and cords bare; in these unpleasant circumstances, however, the parts will often with great rapidity become covered with new integument. The œdema of the penis usually subsides of itself, or after making a few punctures in it; should its integuments, however, threaten to slough, a free incision must be made into it, or the prepuce must be slit up.

Erysipelas of the Pudenda is occasionally met with in ill-fed unhealthy children in whom cleanliness is neglected. The parts become dusky red, swell considerably, and quickly run into gangrene, which spreads up the abdomen or down the nates. It may prove fatal by inducing peritonitis or exhaustion. In the *Treatment*, ammonia, bark, and chlorate of potash, with good nourishment, and a little wine, are the principal means, at the same time that the parts are bathed in a warm antiseptic solution and well fomented.

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Erysipelas of the Fauces may be due to extension of the disease from the head and face to these parts; or it may commence as a primary affection, occurring perhaps at the same time that the rash appears on the cutaneous surface of some distant part of the body. When the fauces are erysipelatous, they present a bright crimson or scarlet colour, with some swelling and thickening of the soft palate and uvula; the patient also most commonly has huskiness or complete loss of voice, and occasionally some croupy symptoms. The glands at the angle of the jaw are always swollen and tender. At the same time there is a good deal of febrile disturbance, with a pungent hot skin and quick pulse. This form of erysipelas is peculiarly contagious, and occurs not unfrequently in the attendants of those who are labouring under some of the other varieties of the disease; of this I have seen numerous instances. In many cases, also, it is epidemic, spreading through a house and affecting almost every inmate.

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Erysipelatous Laryngitis is extremely dangerous. The inflammation, commencing in the fauces, rapidly spreads to the mucous membrane and loose submucous areolar tissue external to and within the larynx, giving rise to extensive œdematous infiltration, which, by obstructing the rima glottidis, may readily suffocate the patient. In consequence of this special tendency to œdema, the disease has by many writers been termed "*œdematous laryngitis.*" After death, the submucous areolar tissue of the fauces, that about the base of the epiglottis, and especially that which enters into the arytæno-epiglottidean folds and that covering the posterior part of the larynx, will be found to be distended with serum or a sero-puriform fluid. This infiltration reaches to the rima of the glottis, and, extending into the interior of the larynx, gives rise to such swelling that its cavity is nearly obliterated. Great as the swelling may be in all these parts, however, it never spreads below the true vocal cords. This fact, which is very important, is explained by the mucous membrane being adherent to the fibrous tissue of which these structures are composed, without the intervention of any submucous areolar tissue. The progress of this œdematous inflammation of the mucous membrane and loose submucous tissue in these situations, is often amazingly rapid, the swelling being sufficient to induce suffocation at the end of thirty-six or forty-eight hours or even sooner. If the patient be not carried off in this way, there will be a great tendency to suppuration and sloughing of the affected tissues, leading perhaps eventually to death from septicæmia or pyæmia.

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Erysipelas of the Serous Membranes was formerly supposed to be of common occurrence, all those cases of diffuse inflammation which are now regarded as of septic origin being at one time classed as erysipelatous. It is highly probable that some cases of diffuse meningitis and peritonitis following injuries of the head and abdomen are truly erysipelatous and dependent upon a specific virus ; but in by far the greater proportion of these cases the inflammation is due to the diffusion of decomposing discharges over the surface of the serous membrane.

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Treatment.—As soon as the patient complains of acute pain and tenderness, and redness and swelling are evident in the finger, an attempt should be made to find the exact locality of the pus by pressing on the finger with some blunt instrument such as the point of a pencil. If an acutely tender spot be found the finger must be soaked in hot water to soften the cuticle, which must then be carefully shaved away with a very sharp knife. In this way a small drop of pus may often be let out from between the epidermis and the cutis, and the whole trouble nipped in the bud. A little wet boric acid lint may then be applied and the finger soon heals. If it have extended beneath the nail the loosened portion must be cut away with scissors to give a free exit to the pus, or in extreme cases the whole nail must be removed. A little iodoform may be dusted on the surface, and a boric lint dressing applied. The strong lead lotion (p. 216) is often very useful in these cases.

2. **Paronychia Cellulosa** or **Subcutaneous Whitlow** may arise, as above stated, from an extension of the variety just described. In other cases it is caused by punctured wounds of the finger, especially when made with dirty instruments, and occasionally it arises without evident cause. In it the pus is diffused through the fat and areolar tissue forming the pulp of the finger. It runs the ordinary course of cellulitis elsewhere. The ungual phalanx becomes swollen, tense, red, and most acutely tender. The redness may soon extend to the whole finger, red lines of inflamed lymphatics may be seen running up the arm, and the axillary glands may become swollen and tender. If unrelieved by treatment, the pus, being unable to point through the thick cuticle of the finger, especially in the horny hands of working men, becomes diffused through the whole pulp. The areolar tissue sloughs, and as in this situation it is intimately connected with the periosteum of the ungual phalanx, this also perishes and the bone necroses. If still left unrelieved it most commonly raises the cuticle, and finally this gives way and exposes a sloughing opening in the cutis, through which, if a probe be passed, the bare ungual phalanx may be felt. In some cases, before the pus finds exit externally, it may have extended into the sheath of the flexor tendons or the distal joint of the finger.

Treatment.—In this form also an attempt must be made to find the pus early by shaving away the cuticle, as at first it is often very limited in amount and superficial. If this fails and the symptoms are not very acute, the finger must be thickly coated with glycerine and belladonna, and wrapped in a few layers of hot wet lint, over which must be placed some gutta-percha tissue made into a cot by sealing its edges with chloroform. The finger must then be wrapped in cotton-wool and the hand elevated. Under this treatment the inflammation may subside without suppuration. Soaking the hand at intervals in hot water gives great relief. If, in spite of this, the symptoms become more marked, a longitudinal incision must be made in the middle line of the pulp of the finger. It must be remembered that the tense swollen pulp gives a sensation exactly resembling fluctuation, for which it may readily be mistaken. After the pus is evacuated the wound should be treated by some antiseptic dressing, and usually heals quickly.

3. **Paronychia Osseosa** or **Periosteal Whitlow** is a rare form in which the inflammation commences deeply in the pulp in immediate contact with

the periosteum of the phalanx. It is said most commonly to follow severe pinches or contusions of the finger. It is characterised by intense throbbing pain shooting up the arm. The symptoms develop rapidly, with a good deal of constitutional disturbance. The pulp of the finger is very tense, and the redness extends to the other phalanges. The *treatment* consists of a free incision to the bone in the middle line of the pulp. The phalanx will be found bare and already separated from its periosteum.

The *treatment of a necrosed ungual phalanx*, either arising from this form of whitlow or the preceding, consists in removal of the dead bone through the incision in the pulp. The phalanx should never be amputated, as a useful extremity to the finger is always left after removal of the bone.

4. **Paronychia Tendinosa, Thecal Abscess,** or **Suppuration in the Sheaths of the Flexor Tendons,** is a more serious condition than the preceding, and is fraught with danger to the finger or hand. It may arise as the consequence of a punctured wound penetrating the sheath, or by extension from one of the other varieties of whitlow. The whole finger, both back and front, swells considerably, becomes red and tense, with much throbbing and shooting pain. The affected finger is semi-flexed, and any attempt to extend it causes intense pain. The swelling soon extends into the palm at the root of the finger and to the corresponding knuckle on the back of the hand. The swollen palm usually preserves nearly its natural colour, or if soaked in water or poulticed becomes dull white, owing to the great thickness of its cuticle. The most marked redness is usually on the knuckle and at the back of the finger, which may give a false idea as to the situation of the pus. The constitutional disturbance is severe and the temperature considerably elevated.

In this condition, unless prevented by treatment, the pus will extend to the limits of the sheath in which it is contained. The sheaths of the index, middle and ring fingers do not communicate with the common sheath which passes under the annular ligament, but are closed below opposite the heads of the metacarpal bones, and, therefore, in suppuration in these fingers the pus does not extend beyond that point. The sheath of the little finger, on the other hand, always communicates with the general sheath. (Fig. 344.) The sheath of the tendon of the thumb is uncertain: in some cases a special synovial membrane covers the tendon passing under the annular ligament without communicating with the general sheath, in others it joins the common sheath. Thecal abscess in the thumb or little finger is, therefore, far more serious than the same condition in the three middle digits. When the suppuration extends to the common sheath the most prominent symptom which attracts the attention of the patient is the red puffy swelling at the back of the hand. The Surgeon on seeing this will always turn the hand over and examine the palm. This will be found to be tense and tender on pressure. There will be fulness in front of the wrist above the annular ligament, and often some redness. If much pus is present, fluctuation may be felt from the palm to the swelling in the wrist. The fingers are semi-flexed, and any attempt to extend them causes pain, but this is most marked in the thumb and little finger. If an opening exists already in the digital part of the sheath of the thumb or little finger, pressure on the palm will cause pus to flow from it. If an exit be not provided for the pus it may burst through the upper limit of the flexor sheath, and extend between the deep and superficial muscles

of the forearm nearly to the elbow. Owing to the close proximity of the synovial membrane to the interphalangeal articulations and the wrist-joint, it not uncommonly happens that these are opened and destroyed by acute septic arthritis; and thus this condition may necessitate amputation of a finger, or if the common sheath is affected, of the whole hand. Sloughing of the flexor tendons is a very common occurrence in thecal abscess, some inches of the tendon coming away after prolonged suppuration, leaving the finger stiff and useless.

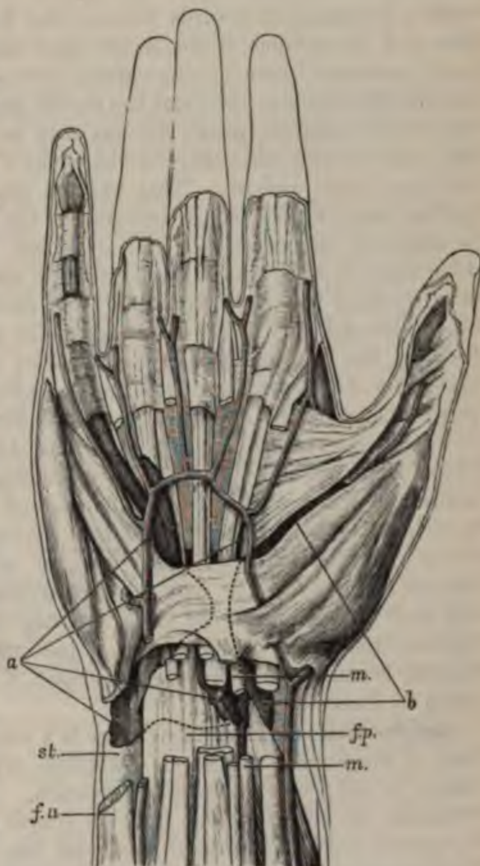


Fig. 344. — Preparation showing the arrangement of the Sheaths of the Flexor Tendons at the Wrist. *a*, Sheath of flexors of fingers; the part which lies in contact with the annular ligament and the upper limit of the part behind the flexor profundus are represented by dotted lines. *b*, Sheath of flexor longus pollicis; the part which lies in contact with the annular ligament is represented by a dotted line; *m*, median nerve; *f.p.*, flexor profundus digitorum; *f.u.*, flexor carpi ulnaris; *s.t.*, styloid process of ulna.

Treatment.—It is most important in all cases of thecal abscess that the pus should be let out early and by free incisions, in order to avert the complications above mentioned. To do this the patient should be put under an anæsthetic, and the limb rendered bloodless by elevation and the application of a tourniquet. A median incision on the finger, not opposite one of the interphalangeal articulations, is then carefully made towards the affected sheath. It may be that the pus is in close contact with the sheath and not in it; if the limb be bloodless this can usually be recognized, and the complication of opening the synovial membrane avoided. If the swelling extends from the finger to the palm the thecal abscess may be opened, without danger of wounding the palmar arches or any important nerves, by cutting towards the head of a metacarpal bone upon the bone itself and parallel to its axis, so as to avoid the interdigital spaces. Heath and Morrant Baker have especially insisted upon the advantages of this method of opening a thecal abscess and thus avoiding the median incision on the finger. They recommend that incisions on the finger in cases of whitlow should be placed laterally so that a healthy sheath may not be accidentally opened.

If the common sheath is affected it must be opened above the annular ligament at the wrist.

If the little finger has been the starting point of the mischief the incision

may be made to the ulnar side of the middle line. It must be carried carefully down to the tendons of the superficial flexor, which here have some fleshy fibres attached to them. The tendons and bellies of the muscles must then be separated with blunt hooks and the handle of the scalpel, and the pus will be found in the space between them and the deep flexor, or between the latter and the pronator quadratus. In Fig. 344 it is seen how the common sheath sends a prolongation inwards between the front of the styloid process of the ulna and the tendon of the flexor carpi ulnaris. Here also the sheath may easily be opened by an incision carried vertically upwards from a point midway between the pisiform bone and the styloid process of the ulna. If the thumb has been the starting point, the pus may be in a separate sheath to the outer side; the incision must therefore be made, if possible, along the inner side of the flexor carpi radialis. This has the disadvantage of being close to the median nerve, which may be irritated by the drainage-tube, but if the incision be made on the outer side of the tendon, the radial artery is endangered. After these openings have been made the sheaths should be syringed out with perchloride of mercury (1 in 1,000) and drainage-tubes inserted. If the pus bursts beyond the limits of the synovial membrane and burrows upwards between the deep and superficial muscles, it can be reached only from the inner side of the arm by a free incision along the outer border of the flexor carpi ulnaris, as the radial origin of the flexor sublimis comes in the way on the other side. (See ligature of Ulnar Artery in the middle of the arm, Chap. XLIV., Vol. II.) In the after-treatment of these cases some efficient antiseptic dressing should be applied, and much relief is afforded by hot boric acid baths. A contracted and useless hand may be left; or in spite of all that can be done, the wrist-joint may be destroyed and amputation become necessary. The only hope of saving a useful hand lies in very free and early incisions, and the use of drainage-tubes and antiseptics in the subsequent treatment. If the hand is put upon a splint, the fingers must be slightly flexed, so that if adhesions form, it may be possible to break them down by forced extension.

Senile Teno-Synovitis.—There is a form of acute suppurative inflammation of the fingers and hand sometimes extending to the wrist-joint, which occurs in old people of feeble constitution. It usually arises from some trivial irritation or infection, and runs its course of disorganization with rapidity. It appears to be a disease of the hand due mainly to senile degeneration, in this respect resembling the gangræna senilis of the foot, but differing in its more acute character and suppurative tendency. The joints of the fingers, metacarpus and carpus, become disorganized and the bones necrose. This disease requires an active tonic and nutritive treatment. The affected parts should not be too much soddened by wet applications. Amputation, partial or complete, may at last be required.

CHAPTER XXXIII.

SEPTICÆMIA AND PYÆMIA. TETANUS.

DEFINITIONS.—The terms "septicæmia" and "pyæmia" have been used with different meanings by different authors, and before proceeding to discuss the affections to which they are applied, it is necessary to define the sense in which they will be used here.

The term **Septicæmia** is applied to a constitutional disorder produced by the entrance into the blood-stream of a poison generated in a wound the discharges of which are undergoing putrefaction or fermentative changes. The resulting process is not accompanied by the formation of secondary centres of inflammation or suppuration. Experiments on animals have shown that two distinct forms of disease may arise from the entrance of putrid matter into the blood-stream. First, an acute general affection, not infective in character, resulting from the admixture of the chemical products of putrefaction with the blood; the poison does not increase in the system, and its effects are proportional to the dose. Secondly, a true infective process, dependent on a specific virus, which multiplies in the body like that of an acute specific fever, so that its effects are not proportional to the original dose. The former of these conditions has received the name of **septic poisoning** or **septic intoxication**, the latter that of **septic infection**. By some authors the infective form of septicæmia has been described under the name of pyæmia simplex.

Pyæmia is a general infective process consequent upon the dissemination throughout the body, by the blood-stream, of a pyogenic virus derived from a local focus of suppuration. It is accompanied by the formation of secondary centres of suppuration disseminated throughout the body. The name "pyæmia" was originally derived from the theory that the condition was due to the entrance of pus into the blood-stream, and, although this theory is no longer regarded as true, the word has come to have so definite a clinical significance that it would be inconvenient to change it. Pyæmia almost invariably arises in connexion with wounds the discharges of which are in a putrid condition, and consequently it is frequently complicated with septic poisoning. It may arise also from wounds or sores which have previously been attacked by cutaneous erysipelas, diffuse cellulitis, or hospital gangrene. It is evident, therefore, that in actual practice these various secondary diseases often become more or less confused together, giving rise to forms apparently intermediate between the different affections, which have led to much confusion with regard to them.

EXPERIMENTAL INVESTIGATIONS INTO THE NATURE OF SEPTICÆMIA AND PYÆMIA.—The first experiments on this subject were made by Gaspard in the early part of this century and first published in 1822, since which time investigations have been almost continuously carried on up to the present time by Virchow, Panum, O. Weber, Billroth, v. Bergmann, Burdon Sanderson, Chauveau, Koch, Hueter, Klebs, and many others. The literature of the

subject is now so vast that it is impossible here to give more than the briefest possible summary of the results that have been obtained.

If a septic liquid, such as putrid blood or serum, or water in which animal tissues have been macerated, be carefully filtered and injected either into the subcutaneous tissue or directly into a vein of an animal, certain definite symptoms are produced. If the dose injected be in sufficient quantity to prove fatal, the first symptom is a slight shudder, followed by some muscular twitchings and restlessness; but muscular power soon begins to fail and the animal falls on its side. In the meantime vomiting and profuse diarrhœa with tenesmus set in; the ejecta being at first feculent, but rapidly becoming serous and tinged with blood. Dyspnœa comes on, power over the voluntary muscles is still further lost, and death ensues apparently from failure of the heart's action. The temperature rises at first from three to four degrees and then gradually subsides, rapidly falling at last to one or two degrees below the normal as the animal dies. The fatal effect is produced in from two to three hours, or even less, to twenty-four hours, or more, according to the dose. If the quantity injected be insufficient to cause death the animal quickly recovers its normal health, even though severe gastro-intestinal symptoms may have been induced. When smaller doses are used a febrile disturbance of limited duration is the only result.

If an animal killed in this way be examined after death, tolerably uniform appearances are met with: the blood is dark-coloured, and sometimes imperfectly coagulated, the inner coat of the vessels and the endocardium are darkly stained, and the serum is reddened by the colouring matter of the red corpuscles, which have become, to a certain extent, disintegrated in the blood even before the death of the animal. Small extravasations of blood (petechiæ) are found beneath the pericardium and pleura, and occasionally in other parts; the lungs are congested, the glandular viscera swollen, and the spleen enlarged, soft, and pulpy. The mucous membrane of the intestines is intensely injected, and its epithelium is found to have been separated.

Further experiments have shown that the blood in an animal thus killed is not infective, and contains no recognizable microscopic organisms. The process is, therefore, assumed to be one of simple poisoning by a chemical poison, and no more an infective process than if arsenic or any similar substance were injected into the blood-stream. The investigations of Brieger, Selmi, Gautier, and others have shown that the so-called "*ptomaines*" derived from decomposing animal fluids are alkaloidal in nature. In chemical composition they are extremely complicated, but can be obtained in a pure crystalline form. The first substance of this kind was obtained by Panum in 1856, and to it the name of "*Sepsin*" was given by Bergmann. It was made by adding strong boiling alcohol to a filtered meat-infusion which had become putrid; the precipitate thus obtained was dissolved in water, and the clear solution gave rise, when injected, to the characteristic symptoms of septic poisoning. The clear solution of the septic poison was perfectly free from microscopic organisms. The relation of micro-organisms to the process of putrefaction has already been discussed (p. 177 *et seq.*); and assuming the germ theory of decomposition to be true, bacteria, although not themselves concerned directly in the production of the symptoms of septic poisoning, are essential to the production of the poison. That they are not the actual poison was shown by Hiller, who collected a mass of the ordinary bacteria of putre-

faction on a filter, washed them in distilled water, and then injected them into animals, and also into his own body, without producing any evil effect. That the bacteria had not been injured was shown by control experiments in which their power of growing and causing putrefaction in organic solutions was demonstrated.

Those experiments may, therefore, be said to show that in the process of putrefaction a complex substance is formed which possesses intensely toxic properties, in small doses giving rise to severe febrile disturbance, in large doses causing a fatal illness accompanied by definite symptoms. The affection thus produced in its most intense form is spoken of as septicæmia, but to avoid confusion is better termed *septic poisoning.* The effect produced by a smaller dose forms, as has already been pointed out, one form of so-called traumatic fever.

The injection of putrid animal fluids into the subcutaneous tissue or blood-stream is not, however, in all cases followed merely by poisoning from the chemical products of putrefaction. Under certain conditions a true infective process ensues, as was first pointed out by Davaine. Perhaps the best example of this process is furnished by the experiments of Robert Koch, in which putrid fluids, such as blood or meat-infusion, were injected into house mice beneath the skin of the back. If the quantity used was sufficient the animals died with all the symptoms of septic poisoning in four or five hours. When one drop only was injected about two-thirds of the mice recovered without any serious symptoms, but in the remaining third, after twenty-four hours of apparent health, a definite illness set in which invariably terminated fatally in from forty to sixty hours after inoculation. The first symptom was a dulness of the eye, with increased secretion from the conjunctiva; the animal became languid, ceased to eat, and finally sat still with its back bent and its legs drawn under it. Its respirations gradually became slower and death came on almost imperceptibly. On examining it after death some local inflammation, with serous exudation, was found at the seat of inoculation, but the internal organs showed no marked change beyond some swelling of the spleen. If the point of a knife was dipped in the blood, or in the exudation at the seat of inoculation, and a mere scratch was then made with it on the ear or tail of another mouse, death invariably followed with the same symptoms and in about the same time, and thus the disease might be transmitted indefinitely from animal to animal. A drop of the blood from an infected mouse placed on a glass slide, dried, stained with methyl-violet, and mounted in Canada balsam, was found to contain vast numbers of very delicate bacilli, about $\frac{1}{2500}$ of an inch long, and one-eighth of their length in breadth. Many of these were seen to have penetrated into the substance of the white corpuscles, and apparently to have multiplied within them.

An attempt was made to transmit the disease to animals of other species, but without success. Even the field mouse, though apparently so nearly allied to the house mouse, was found to be incapable of receiving the poison.

A general infective process was induced by Davaine in a similar way in rabbits by the inoculation of putrid fluids; but the organism found in the blood in that case was a micrococcus not a bacillus. Both Davaine and Koch found that the infective process was more certainly induced by fluids in an early stage of decomposition.

The infective processes arising in this way have been described as "septicæmia" by both Davaine and Koch, but as that term is also applied to the simple chemical poisoning from putrid matter, it is better to speak of the infective disease as *septic infection,* and of the non-infective as *septic poisoning.*

The foregoing experiments have shown, therefore, that an acute infective process, unaccompanied by the formation of secondary centres of inflammation, can be induced both in mice and in rabbits by the injection of putrid animal fluids beneath the skin.

Koch succeeded in further experiments in producing an infective disease, in which the development of secondary centres of inflammation formed a part of the process. A fluid, prepared by macerating a piece of the skin of a mouse, was injected beneath the skin of a rabbit. After two days the animal became ill and gradually growing weaker died 105 hours after the injection. The *post-mortem* examination showed a diffuse purulent inflammation at the seat of inoculation, which had extended to the peritoneum; the spleen was swollen and the liver contained grey wedge-shaped patches, and dark red airless spots the size of a pea were found in the lungs. Micrococci were found in great numbers throughout the body, especially in the parts that had undergone changes visible to the naked eye. In the vessels in many parts, dense masses of micrococci mixed with red corpuscles were found adherent to the walls, and Koch felt justified in coming to the conclusion that capillary thrombi were thus produced, and that the patches in the lungs and liver were caused in this way. In the metastatic deposits, not only were the vessels plugged with mixed red corpuscles and micrococci, but the organisms had penetrated the walls of the vessels and were invading the surrounding tissues. Some blood from the affected animal injected beneath the skin of another rabbit produced essentially the same condition which terminated fatally in forty hours. The disease thus induced was, therefore, a general infective process accompanied by secondary or metastatic deposits closely resembling those met with in pyæmia in man.

Lastly, numerous experiments have been made by Cruveilhier, Sédillot, Virchow, O. Weber, Henry Lee, Savory, and many others with the view of ascertaining the part played by embolism in the production of the secondary abscesses in pyæmia. The result of these has been to show, that if a fluid holding in suspension solid particles of sufficient size to lodge in the smaller arteries of the lung be injected into the blood-stream, the effect produced will depend upon whether the solid matter is irritating or not. Non-irritating emboli lodging in the terminal arteries of the lung cause the part cut off from the direct blood-supply to be intensely injected with blood. The walls of the capillaries soften and give way, and hæmorrhage takes place into the tissue of the lung. A wedge-shaped airless patch is thus formed of dark purple colour on the surface, or as it is called a *hæmorrhagic infarct.* The whole infarct is gradually absorbed without suppuration, leaving a cicatrix on the surface. O. Weber also states that very fine solid particles may pass through the capillaries of the lung and give rise to embolism in the course of the systemic circulation. Should the embolus, however, possess irritating properties, the infarct softens and breaks down, inflammation and suppuration following in the surrounding tissues, and thus an abscess is formed. If the irritating embolus be so small as to lodge in the capillaries only, it will directly excite inflammation and suppuration at the point at which it lodges. The

experiments have shown that similar results follow whether the embolus owes its irritating properties to its mechanical condition, its chemical composition, or to its containing a specific virus. Thus abscesses in the lung have occasionally followed the injection of charcoal, and mercury. Decomposing fibrin or blood-clot or putrid fat never fails to produce them. If the emboli enter the general circulation, abscesses may form in other viscera or tissues. These observations show that the existence of secondary or metastatic abscesses does not necessarily indicate a true general infective process, as the causes of the disseminated local inflammations may be carried by the blood without developing or multiplying in that fluid.

Experimental pathology has thus thrown great light upon the nature and causes of septicæmia and pyæmia, but much still remains to be explained. It will be noticed that the genuine infective diseases are associated with the presence of definite microscopic organisms which, there is every reason to believe, stand in a direct causal relation to the process, yet they all arise from the injection of apparently similar putrid fluids. Microscopic examination shows that in the early stages of putrefaction numerous different organisms—bacilli, bacteria, and micrococci—are found in the putrid fluid; but it has not been clearly shown that each of the forms subsequently found in the blood of the affected animals is present. As putrefaction advances, the ordinary septic bacteria which, as shown by Hiller, cannot develop in a living animal, become more abundant, choking the other forms, and this fact has been suggested as an explanation of the diminished virulence of the fluid after the second day.

Septic poisoning by the chemical products of putrefaction can be produced with certainty in any animal by the injection of a sufficient dose of the putrid fluid. The symptoms produced are nearly identical in all species, though some animals, as the rodents, suffer more severely than the carnivora. On the other hand true septic infection cannot always be produced at will. The same dose of the same fluid injected into different animals of the same species may induce the disease in some and fail in others; and different species are differently affected. It is evident therefore that there are other causes dependent upon the animal itself, which are essential to the development of the infective disease, and of the nature of these we are still ignorant. When once, however, the disease is developed, it can be communicated from one animal to another of the same species with perfect certainty; but frequently it is incapable of being transmitted to animals of a different species.

Our knowledge may be briefly summarised thus: All putrid animal fluids contain a chemical poison which, if absorbed, will cause a constitutional disturbance proportional to the dose, and they frequently, and perhaps always, contain also a virus capable under favourable conditions of setting up a true general infective disease; lastly, should solid particles, as from a softening thrombus, enter the blood-stream, they will, if impregnated either with the simple chemical poison or the specific virus, set up disseminated centres of inflammation and suppuration wherever they lodge. The importance, therefore, in regard to the prevention of pyæmia and septicæmia, of avoiding putrefaction in the discharges of wounds cannot possibly be over-rated.

Although the conditions in a wound in the human subject are somewhat different from those present in experimenting on animals, yet the analogy is close enough to justify us in applying the results obtained to surgical practice.

A recent wound with decomposing discharges, or a deep cavity with pent-up putrid pus in it, are conditions essentially similar to those obtained by injecting a syringeful of a putrid fluid beneath the skin of an animal.

Causes of Septicæmia and Pyæmia.—Simple septic poisoning may occur whenever a sufficient quantity of decomposing blood, serum or pus is collected in a wound or cavity of the body. Putrefaction, as before pointed out, will occur in such collections of fluid under all ordinary conditions to which a patient is exposed either in hospital or private practice. Septic poisoning affects a patient debilitated by want of proper food and bad hygienic conditions more severely than one placed in better circumstances; beyond this, however, the surroundings of the patient exercise but little influence on its occurrence. The causes of the process are to be looked for in the wound itself, and septic poisoning may always be prevented by efficient drainage and antiseptic treatment.

The genuine infective processes will on the other hand rarely develop in spite of the presence of decomposing matter in the wound except when the patient is placed under unfavourable hygienic conditions. The experiments already described, in which septic infection and pyæmia have been induced artificially by the injection of putrid fluids beneath the skin of an animal, show that the presence of decomposing matter is an important element in the causation of these diseases. Clinical experience has fully confirmed this fact. Pyæmia has been practically banished from many hospitals in which it was formerly a frequent cause of death merely by the adoption of antiseptic methods of treating wounds—ventilation, cubic space, and other conditions surrounding the patient being unchanged. On the other hand, a strict attention to the laws of hygiene has been almost equally successful in preventing these diseases even when the Surgeons have not adopted any special mode of antiseptic treatment.

These diseases are predisposed to by all conditions, either before or after operations or injuries, that tend to impair the health, and to lower the strength, such as constant want of fresh air, overcrowding, abuse of alcohol, and insufficient or improper food. Of all these causes, overcrowding is undoubtedly the most frequent and the most fatal; more particularly is this injurious, if many patients are suffering from suppurating wounds. That pyæmia is the result of the faulty hygienic conditions just alluded to, viz., want of pure air, overcrowding, and insufficient and unwholesome diet, is evident from the fact of its being most destructive where these causes of disease prevail, as amongst the poorer classes of all large and densely peopled towns; while in the purer air of country districts, or in private practice amongst the wealthier classes, it is rarely met with. It is one of those causes of death after operations that might and ought to be prevented; and wherever it is frequent, we may be sure not only that proper attention is not being paid to cleanliness and the prevention of decomposition in the treatment of the wounds, but that either the constitutions of the patients are peculiarly deteriorated, or else that the hygienic conditions to which they are exposed after the injury or operation are more than usually faulty. That it may be prevented has been abundantly proved by the experience gained in the Franco-German war of 1870. The fact, which had previously been well known to all scientific Surgeons, was then established beyond all possibility of cavil, that the danger of pyæmia increased, *cæteris paribus*, in proportion as the hygiene was faulty

and as wounded patients were closely crowded, so that the atmosphere surrounding them became contaminated by fœtid exhalations from the decomposing discharges of suppurating wounds. It was found that, in the great mass of the wounded, pyæmia was developed among those who were aggregated within the walls of hospitals or regular buildings, such as churches, barns, school-houses, and conservatories, which, though clean and airy, did not admit of thorough ventilation ; while it was far less common among wounded soldiers of exactly the same class who were treated in hastily constructed open and draughty huts.

SEPTICÆMIA.

The two forms of disease known as septicæmia, septic poisoning, and septic infection, are not always to be clearly distinguished from each other in surgical practice, partly because the symptoms of the two affections closely resemble each other and partly because the true infective process is frequently complicated or preceded by the non-infective. They are sufficiently distinct, however, to justify a separate description.

Septic Poisoning, Septic Intoxication, or, as it has sometimes been called, **Sapræmia**, is the general affection produced by the absorption of a sufficient dose of the chemical products of putrefaction to endanger life. The milder effects of the same poison are classed as septic traumatic fever. Such a division as this is unscientific, and will no doubt before long be done away with, but at the present time to speak of the milder forms of septic wound-fever as septicæmia would only increase the confusion already existing.

For septic poisoning to take place it is necessary that there should be a considerable quantity of decomposing matter so situated that absorption of the poison can readily take place. The conditions under which it is most likely to occur, therefore, are large and irregular wounds, such as those resulting from compound fractures of the bones of a limb ; hollow wounds, such as those left by the removal of tumours ; wounds of joints ; wounds involving the pleura and peritoneum, and large abscesses opening externally by an insufficient aperture. Perfect drainage of injuries of this kind so far limits the quantity of septic matter as to render acute septic poisoning almost impossible. Absorption takes place most readily from recent wounds, and serous or synovial cavities. When suppuration has set in absorption takes place much less readily, as healthy granulations take up the poison with difficulty, unless the septic matter is pent up in contact with them at some degree of pressure.

The **symptoms of acute septic poisoning** are the following. On the second day after the injury or operation the temperature rises considerably, reaching from 103° F. to 104° F., or even higher. The skin is dry, and feels hot to the hand. There may be a chill or even a severe rigor, but this is by no means constant. The patient feels very ill, there is complete loss of appetite, with headache, a quick pulse, and a dry furred tongue. Delirium usually sets in at night, and occasionally is violent. By the third day after the injury some disturbance of the alimentary tract sets in. Vomiting is common, but diarrhœa is not frequent. In very acute cases the symptoms of collapse quickly come on. The pulse is rapid, feeble, and irregular, the tongue brown and dry, and the lips covered with sordes ; the temperature

falls, and may sink even below normal, consciousness is lost, and the patient may become comatose before death. Dyspnœa is a common symptom during the last days. The skin may assume a yellowish tint before death. The urine frequently contains albumen.

In cases in which the septic matter which is causing the mischief is in the cavity of the pleura or peritoneum the symptoms may set in and prove fatal before the end of the third day. When the primary mischief is a large wound of the soft parts, or a compound fracture, the symptoms may be less severe and the duration of the case may extend to a week or more before death takes place. In these less acute cases the temperature is lower; vomiting and diarrhœa are common; there is rapid emaciation with loss of strength, death finally occurring rather from exhaustion than collapse.

In contrasting these symptoms with those produced in animals by the injection of putrid fluids beneath the skin, it will be seen that there is a general resemblance, which is quite as close as could be expected when the differences in the conditions are considered. In experimental septic poisoning the full dose is injected once for all under the skin, or into the blood; if in sufficient quantity it is speedily fatal, if not the animal recovers. In septic poisoning, as it occurs in man, the process of putrefaction gradually develops in the putrescible matter in the wound, and the symptoms consequently are more slowly manifested. The local inflammation caused by the pent-up septic discharges is necessarily accompanied by exudation, which maintains a constant supply of fresh decomposable matter, and consequently a continuous development of the poison takes place. The symptoms are in fact as a rule the result of the prolonged administration of a moderate dose of the septic poison rather than of the sudden entrance of a fatal quantity into the blood-stream.

The **Post-mortem Appearances** are almost identical with those observed when the disease is produced artificially in animals. In extremely acute cases the signs of decomposition set in early, and the surface in a few hours after death becomes marked by lines corresponding to the superficial veins. Rigor mortis is often feebly marked. On opening the body the blood may be found imperfectly coagulated and dark in colour, but this is by no means common. A slight excess of serum, often darkly stained with the colouring matter of the blood, may be found both in the pericardium and the peritoneum. The heart is flabby, and marked in many cases by small extravasations of blood (petechiæ) beneath the pericardium, usually most abundant at the back of the organ. Similar petechiæ may also be found beneath the pleura and peritoneum. On opening the heart the endocardium is found darkly stained, even at an early period after death. The lungs always show marked hypostatic congestion, their posterior part being dark purple, swollen and œdematous. The liver and kidneys are swollen and often full of blood, and the spleen is swollen and soft, sometimes almost diffluent. The mucous membrane of the alimentary canal is often congested, but with nothing approaching to the intensity met with in animals.

The *post-mortem* appearances are due, first to the changes in the blood, the most marked of which is the rapid disintegration of the red corpuscles, causing the staining of vessels and tissues. This disintegration takes place in extreme cases before death. The corpuscles are found not to run together in rouleaux but to form irregular clumps. This has also been observed during

life, and the blocking of the vessels by these masses of corpuscles is probably the cause of the capillary hæmorrhages found throughout the body. Secondly there is a marked tendency to passive congestion of the viscera consequent on the feeble action of the heart before death; and, lastly, there is cloudy swelling of the epithelium of the glandular viscera.

In more chronic cases of septic poisoning similar changes are found, but less marked in proportion to the chronicity of the case.

Diagnosis.—Septic poisoning can be confounded only with some malignant specific fever, but the connexion of the symptoms with their cause is in most cases so evident that an error is scarcely likely to be made. In former times many cases of septic poisoning after operations were classed as collapse, or exhaustion.

Prognosis.—The prognosis depends upon the severity of the symptoms and the possibility of removing the cause. If the accumulation of septic matter can be cleared away and its re-accumulation prevented, cases apparently hopeless may sometimes recover.

Treatment.—The treatment consists in removing the cause, as by laying a joint freely open, enlarging the aperture in an imperfectly opened abscess, or establishing good drainage in a cavity, as the peritoneum or pleura, or in a wound. The occurrence of septic poisoning can always be prevented by antiseptic treatment, and efficient drainage. The patient's strength must be kept up by stimulants and liquid food.

Septic Infection.—An acute general disease accompanied by symptoms closely resembling those just described as resulting from septic poisoning is occasionally met with in circumstances which preclude the possibility of its being due merely to the absorption of a chemical poison. The conditions which would lead us to believe that a given case is the result of a true infective process are, first, its arising from a wound of such size as to render it impossible for the necessary dose of septic matter to be formed in it; secondly, evidence of infection from one patient to another; and, thirdly, the presence of active living organisms in the blood. The first condition is met with in those cases of septicæmia that follow the inoculation of the poison of dead bodies, by a scratch or puncture during a *post-mortem* examination. In these the local inflammation may be very slight, the patient dying rapidly from blood-poisoning. Similar cases are sometimes met with after operations in which the wound is too small to furnish a fatal dose of the chemical products of putrefaction. The second condition, infection from another patient, is seldom observed in surgical practice. It is, however, very marked in the septicæmia which forms one of the varieties of puerperal fever, the intense infectiousness of which is but too well known. The last condition, the presence of specific organisms in the blood, has been observed in many cases of septicæmia, but our knowledge on this subject is at present very imperfect when compared with that which we possess with regard to septic infection in animals. It must be remembered, however, that until recently the non-infective and infective forms of septicæmia were confounded together, and the methods of observation have only lately been brought to any degree of perfection.

Those cases of septic infection which arise as a consequence of large wounds, the discharges of which are in a state of decomposition, are necessarily complicated to a greater or less degree by septic poisoning, and the recognition of the infective process then becomes correspondingly difficult.

Although at present, therefore, we are unable always to separate septic poisoning and septic infection in actual practice, it is to be hoped that further observation will enable us to do so, for the importance of the distinction is very great. Septic poisoning is not infectious, and can be relieved by removing the local source of the septic poison; septic infection, on the other hand, is supposed to be intensely contagious, and may be readily communicated from one patient to another, and as it is a general or blood-disease no relief can be hoped for from treatment applied to the local source of infection.

Symptoms of Septic Infection.—The disease is usually ushered in by a distinct rigor, often severe, and sometimes repeated more than once. The temperature rapidly rises, reaching 104° F. or 105° F., or even a higher point during the rigor. The subsequent symptoms closely resemble those already described as occurring during septic poisoning. There is delirium, ending in insensibility, and even in profound coma. The pulse is extremely rapid and quickly becomes feeble. The tongue soon becomes dry and brown, and the lips and teeth are covered with sordes. Diarrhœa or vomiting may occur. The skin assumes a yellowish tint, and purpuric spots may appear in it. The temperature may fall and become subnormal before death, or may remain high to the end. Dyspnœa is often a marked symptom before death.

In very acute cases death takes place on the second or third day after the commencement of the disease, but life may be prolonged even for a week.

The **post-mortem appearances** are the same as in septic poisoning—visceral congestion, subserous petechiæ, early and intense *post-mortem* staining, and usually a swollen and softened spleen. In some cases there is pneumonic consolidation of the lung, and there may be pleurisy with blood-stained effusion. It is probable that different forms of micro-organisms may by infecting the blood cause the symptoms of true septicæmia in man. It is known that the pyogenic organisms may under certain circumstances be present in the body without causing suppuration. According to Von Eiselsberg, quoted by Watson Cheyne, staphylococci or streptococci were found in almost all the cases of septic fever which he examined; whilst Monod and Macaigne have recorded five cases of septicæmia in which streptococci were present in the blood.

Diagnosis.—In the present state of our knowledge it is frequently impossible to distinguish septic infection from septic poisoning except in the definite absence of the cause of the latter condition, as in some poisoned wounds. Septic infection is also identical in its symptoms and *post-mortem* appearances with the malignant forms of the acute specific fevers in which the patient dies before the characteristic eruption appears, and unless the source of infection is evident the diagnosis may be very doubtful.

Prognosis.—The uncertainty of the diagnosis necessarily interferes with an accurate prognosis; but when the evidence is strong that the affection is a genuine infective process the case is almost hopeless.

Treatment.—If the case is complicated by a septic wound, means must be taken to remove the septic matter and clean out the cavity with some strong antiseptic solution, as of chloride of zinc (40 gr. to ℥j), or carbolic acid (1 in 20), or perchloride of mercury (1 in 500). The patient's strength must be supported by fluid nourishment, and stimulants and quinine may be given in large doses.

PYÆMIA.

Pyæmia is merely a clinical expression for a pathological process dependent upon the dissemination by the blood-stream of the causes of suppuration derived from a local source of infection. It most commonly, in fact almost invariably, arises as the secondary result of a primary inflammation which has reached the stage of suppuration, and the name was derived from the theory that the disease was due to the entrance of the pus into the blood-stream, or "purulent absorption." Although in the great majority of cases in which pyæmia comes under the observation of the Surgeon it occurs as a complication of wounds or injuries in which the discharges are in a state of putrefaction, this is not invariably the case. Thus, in the disease known as acute necrosis of bone, pyæmia often sets in before the subperiosteal abscess has been opened, and when the pus is perfectly free from any signs of decomposition. The primary disease in this case is, however, itself an infective process, and not a simple inflammation. Pyæmia is frequently met with as a consequence of other specific suppurative inflammations: thus, we see boils, carbuncles, diffuse cellulitis, and phlegmonous erysipelas often precede and lead to its occurrence.

Pyæmia was formerly a very common cause of death after operations and injuries, especially those implicating the veins, bones, or joints. The improved hygienic condition of most hospitals, and the introduction of antiseptics and drainage in the treatment of wounds have almost banished it from surgical practice. In properly constructed and well regulated hospitals and in private practice it is rarely met with except as a complication of cases in which efficient antiseptic treatment is impossible, as in operations on the urinary organs, or as a sequence of some specific inflammation, as carbuncle, acute necrosis, or scarlatinal inflammation of the fauces.

In some rare cases the symptoms and *post-mortem* appearances of pyæmia are observed without any primary inflammation being found. These cases have been described as idiopathic or spontaneous pyæmia.

The nature of the poison and its mode of entrance into the system will be discussed with the pathology of the disease.

Pyæmia is characterized especially by two series of phenomena: 1. A peculiar train of Constitutional Symptoms attended with a state of great depression of the powers of the system; 2. the formation of Abscesses, and the occurrence of diffuse inflammations in various parts of the body. The disease may be acute, subacute, or chronic. Usually it is subacute, and often chronic. Whatever form it may assume, the symptoms are essentially the same, differing only in degree.

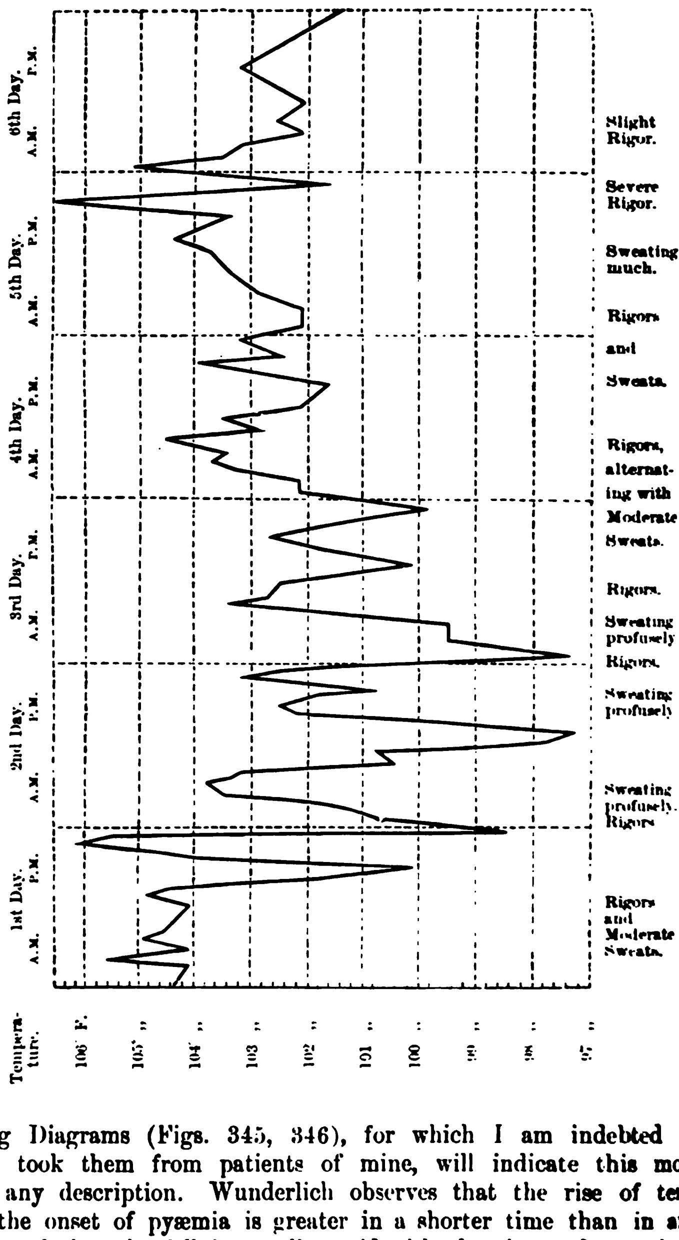
Symptoms.—The invasion is as follows: During the period of apparently ordinary febrile disturbance, the patient is seized with a rigor, usually very severe and prolonged. The rigor presents no difference from that met with in the invasion of many other specific febrile affections (p. 197) except in its severity. In some cases of pyæmia the rigor is not repeated, but more frequently it recurs at irregular intervals of from twenty-four to forty-eight hours; and, as the disease becomes established, even twice or oftener in the day. A single rigor, although a very alarming symptom, may pass off without the development of the disease. The subsequent sweating is very profuse, the

bedclothes being soaked with the perspiration. The rigors are very exhausting to the patient.

The *temperature* in pyæmia presents remarkable and characteristic fluctuations. It is uniformly higher than normal, but rises above and falls in its general level in exact accordance with the development of the rigors. The

Fig. 345.

Temperature Chart in a case of Pyæmia following Primary Amputation of the Foot in a man aged 30.

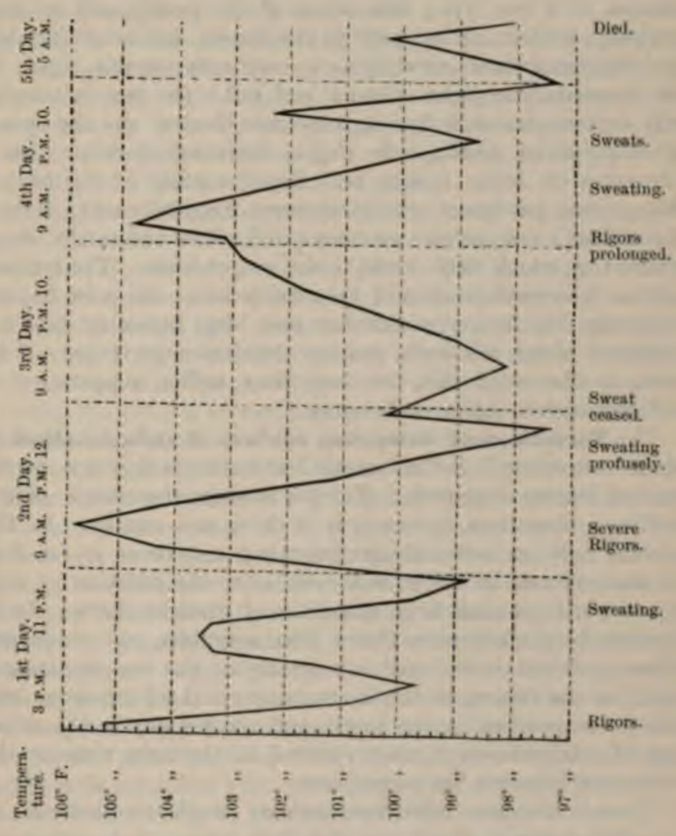


accompanying Diagrams (Figs. 345, 346), for which I am indebted to Ringer, who took them from patients of mine, will indicate this more clearly than any description. Wunderlich observes that the rise of temperature in the onset of pyæmia is greater in a shorter time than in any other disease, and that the fall is equally rapid with the rise, and sometimes

more so. But it does not, as a rule, reach the normal point, and usually ascends again before this is reached. In some cases, however, the temperature falls slightly below normal during the profuse sweating following a rigor, as shown in the accompanying temperature charts. The rise in the temperature precedes the occurrence of the rigors; and the approach of a rigor may be predicted by noting a commencing rise in the thermometer.

Fig. 346.

Temperature Chart in a rapidly fatal case of Pyæmia following a Compound and Comminuted Fracture of the Bones of the Leg.



There are sometimes actually two rigors during one continuous rise of temperature.

Should the rigors recur with some degree of regularity the pyæmia may closely resemble an attack of ague. As a rule, however, the regular periodicity so characteristic of ague is wanting in pyæmia. After the occurrence of rigors other changes begin to manifest themselves.

Any open wound that may exist is usually in an unhealthy state at the time of the invasion of the disease. It is either foul, or sloughy, or inflamed, and discharging decomposing pus, which perhaps does not find a ready exit. Even when the wound appears healthy superficially, it is probable that some pus is deeply pent up within it, or possibly, if the bone is injured, inflammation and suppuration are taking place in the medulla. Pyæmia never arises from

a healthy superficial granulating sore. When pyæmia has set in, the wound usually becomes dry and ceases to discharge pus. Even if the superficial parts remain tolerably healthy, the granulations become pale and healing ceases. In very chronic cases, however, healing may go on while the patient is still suffering from secondary abscesses in different parts of the body. The skin is continuously hot, and has often a burning pungent feel. The breath has that peculiar sweetish, or fermentative smell that is commonly noticed in all febrile diseases of a low type; this odour of the breath, and indeed of the body generally, is often noticed early in the disease, and must then be taken almost as a diagnostic, and certainly as a most unfavourable, sign. The secretions are arrested; the pulse is quick and soft; the face is usually pale, with a very anxious drawn look, but sometimes flushed and the eyes bright; there is hebetude of mind, with slight nocturnal delirium, but perfect consciousness on being spoken to. Rapid wasting of the body sets in about this period; patches of erratic erythema frequently make their appearance on the surface; and the skin assumes a dull sallow and earthy, or a bright yellow icteric tint, which may extend to the conjunctivæ. The symptoms now indicate an extreme depression of the vital powers; the pulse becoming small and fluttering, the tongue, which has been dry, becoming brown, sordes being deposited about the teeth, and low delirium supervening. Usually from the sixth to the tenth day, but sometimes earlier, suppuration commences in different tissues, joints, and organs.

The **Formation of numerous centres of inflammation and suppuration,** "secondary" or "metastatic" abscesses as they are termed, is the most marked feature of pyæmia. The pus in these abscesses is often thin and oily-looking; sometimes, however, it is thick and creamy. In the oily-looking pus the cells are extremely granular, and sometimes so far degenerated that no nucleus can be recognized even after the addition of acetic acid; the liquor puris contains large quantities of granular *débris*. In some cases the pus has been observed to form a firm coagulum, and occasionally it is fœtid. These purulent collections vary greatly in size and in situation. They are found in the viscera, in the intermuscular and subcutaneous areolar tissue, in the serous cavities, in the joints, and occasionally in the muscles, or at the seat of subcutaneous injuries received at the same time as the wound from which the infection has taken place.

Pyæmic abscesses differ from ordinary purulent collections, not only in the peculiar character of the pus that they contain, but more particularly in the rapidity with which they form, a few days commonly sufficing for them to attain a large size. This, with their very widespread character, and the insidious manner in which they occur, often with few if any local signs, constitute the distinguishing features of these collections.

The visceral abscesses vary in size from a pin's head to a walnut; in many cases the organs affected are studded with them. These collections are most frequently met with in the lungs, being seated at the posterior part and on the surface of these organs, or in the interlobular fissures. They form often without cough or pain, and the area of consolidation is rarely sufficient to be recognized by percussion. They are usually rapidly followed by pleurisy with effusion, which conceals any physical signs of the mischief in the lung tissue. The organ that is most frequently affected next to the lung is the liver. Here also the abscesses are usually small and numerous. They can occasionally be

recognized by irregularity of the surface of the liver in the superficial part in the epigastrium and by tenderness on pressure. Jaundice often forms a marked symptom. In some cases, especially when the disease is secondary to dysenteric ulceration of the intestine, the abscess is single and of considerable size. Secondary abscesses are not uncommon in the spleen, where they can only occasionally be recognized by tenderness and pain in the splenic region. They are also met with in the kidney, less commonly in the brain, and, in rare cases, in the parotid gland, the prostate, and testes.

Inflammations of the serous membranes in pyæmia are usually secondary to abscesses of the viscera, but they are occasionally met with independently. There is usually abundant effusion, which rapidly becomes purulent. The pleura is most commonly affected, the peritoneum least frequently. The symptoms of these serous inflammations as a rule present nothing peculiar except in the rapidity with which effusion takes place.

The joints are frequently affected, especially the knees and shoulders; whilst not unfrequently the sterno-clavicular joints are involved. They become rapidly filled with a thin yellowish purulent liquid. This is usually indicated by intense pain, often cutaneous or superficial, with fluctuation and swelling in the joint. Often, however, large accumulations of pus form suddenly in joints, without having been preceded by pain or any other sign of mischief; in these cases the interior of the joint, though filled with pus, remains tolerably healthy, there being no erosion of cartilage or destruction of ligament, but merely some inflammatory injection of the synovial membrane.

When the pus is infiltrated into the areolar tissues and muscles of the limbs and trunk, it forms diffuse collections of a thin serous matter commonly mixed with shreds of the areolar membrane of the part, having no boundary. These collections are met with in the axilla, down the flank and about the back, in the iliac fossa, thigh or calf, and may either be confined to the subcutaneous, or extend to the deep intermuscular, areolar planes in these regions; or they may form even in the muscular substance itself, being diffused between the fasciculi, which are softened and disintegrated. Most commonly the presence of these collections is indicated by patches of cutaneous redness, and by a doughy, œdematous, and boggy state of the superjacent integuments. Sometimes superficial patches of redness with some œdema appear in different parts of the body, afterwards subsiding without the formation of pus, giving rise to one form of the condition known as "erratic erysipelas."

Amongst the rarer complications of pyæmia is acute suppuration of the eyeball, or *metastatic panophthalmitis*. All the structures of the globe are affected. Virchow has shown that it is due to the lodgment of infective emboli in the vessels of the eye. Litten and Leube have observed retinal hæmorrhage in many cases of puerperal pyæmia. In some cases they appeared to be the result of embolism, but in others this seemed doubtful. Plugs of micrococci have been observed in the retinal vessels after death. These conditions are met with only in very grave cases, and usually indicate the approach of death. The ophthalmoscope may therefore sometimes furnish valuable evidence both of the nature of the disease and of its probable termination.

The progress of the disease is usually from bad to worse, sometimes rapidly, but at other times not uninterruptedly so, there being remissions and apparent, though not real, improvement. The patient rapidly wastes, the body becoming shrunken, the muscles soft, and the skin grey or sallow, loose and pendulous;

great debility also sets in. The abdomen becomes tympanitic, diarrhœa or profuse sweats come on; pneumonia or pleuritic effusions declare themselves; delirium, from which the patient is easily roused, alternates with stupor; and at last he sinks from exhaustion. Death takes place usually about the tenth or twelfth day; though it may occur as early as the fourth, or the patient may linger on for six or seven weeks.

POST-MORTEM APPEARANCES.—The body is usually emaciated and rigor mortis is feebly marked. The skin is generally yellowish in tint, sometimes intensely jaundiced. Purpuric spots are occasionally noticed on the surface, especially in the lower extremities. Decomposition as a rule sets in early.

Appearances at the Seat of Infection.—Any external wound is usually grey, sloughy, or dry, and the parts round it may be œdematous. If the wound be one implicating the bones, as an amputation, or an excision of a joint, it very frequently presents the appearances of septic or gangrenous osteomyelitis. The exposed end of the bone is bare, and the periosteum is loosened. If the shaft of a long bone has been implicated, the medullary canal contains gangrenous fat mixed with offensive pus; if the cancellous tissue has been opened up, the spaces are filled with a similar material. (See Osteomyelitis, Vol. II.) In the bones of the skull the diploë may be found infiltrated with pus.

The **Veins** leading from the wound are in some cases perfectly healthy; far more commonly, however, they are found to present marked evidences of disease. While exposing the vein by dissection it will usually be noticed that the areolar tissue in its neighbourhood is infiltrated with inflammatory products for a considerable distance from the wound, and occasionally the vessel may be surrounded here and there by pus. When the vein is exposed, it is seen to be distended, being in parts dark purple, and in parts yellowish, as if filled with pus. On opening the vein its coats are found to be swollen and thickened, and its lumen filled with a thrombus in various stages of softening and disintegration. This thrombus may extend for a great distance, as from the leg to the groin, its extremity sometimes projecting into the main trunk into which the affected vein enters. The fragments of the softened thrombus may thus be carried on into the circulation as emboli, lodging in the lungs and giving rise to secondary abscesses. In some cases the source of the secondary mischief may be recognized by the state of the veins. Thus in cases of osteomyelitis, the thrombosis of the main trunk may commence at the point at which the veins from the bone enter it. In a case in which a patient died of pyæmia after an amputation of the thigh in University College Hospital, the veins leading from the stump were perfectly healthy, while those leading from a foul bed-sore were full of disintegrated clot.

General Post-Mortem Appearances.—The **blood** may be dark in colour and imperfectly coagulated, as in septicæmia, but in the vast majority of cases it presents no naked-eye abnormal appearance.

The veins of distant parts are occasionally found to contain softening thrombi similar to those observed at the seat of infection. In the 110 cases of pyæmia collected by the Committee of the Pathological Society this condition was observed in six. These cases are of great interest as indicating that the general infection of the blood may, in some cases at least, be an important factor in causing thrombosis at the original seat of infection.

Secondary Centres of Inflammation occurred in the following order of frequency, in the 110 cases reported in the Transactions of the Pathological

Society of London, 1879. The table is divided into two columns, A and B, A showing the frequency with which the secondary inflammation was limited to one organ or tissue, and B the number of cases in which the special part was affected in combination with others.

	A.	B	Total.
Joints	12	8	20
Subcutaneous and intermuscular areolar tissue	4	8	12
Muscles	0	1	1
Bruises and other subcutaneous injuries	1	1	2
Serous membranes	6	4	10
Lung	33	24	57
Liver	1	11	12
Spleen	1	10	11
Kidneys	0	6	6
Brain	1	5	6
Heart, substance of	1	4	5
Endocardium	0	1	1
Parotid Gland	0	1	1

The cases of inflammation of serous membranes do not include those in which the mischief was merely secondary to abscesses in the organs they cover. The relative frequency of the affection of the different membranes was as follows: pleurisy, 4; meningitis, 3; pericarditis, 2; peritonitis, 1.

The **Heart** is frequently the seat of small extravasations, which may be found either beneath the pericardial or endocardial lining, or in the muscular substance itself. Sometimes, though not very otfen, abscesses are found situated either in the wall or in the papillary muscles; these are usually small collections of puriform matter, rarely much larger than a pea, and often surrounded by a zone of congestion or hæmorrhage. The muscular substance is flabby, and the lining membrane of both the heart and the aorta is usually more or less deeply stained by imbibition of the colouring matter of the blood. Pericarditis may occur independently or in connection with metastatic abscesses in the heart, or may be secondary to the inflammation of the pleura. Occasionally diffuse acute inflammation of the muscular structure of the heart is found, without any distinct abscess having been formed.

The **Lungs** are much congested, especially at the posterior bases, where the tissue is friable; sometimes this congestion passes into true pneumonia. The most important condition present in pyæmia is the existence of *metastatic abscesses*, which may vary much in number and size. These are usually found scattered over the surface, and are most common in the upper part of the lower lobes, and the interlobular fissure. Their position is indicated by induration and a slight elevation, to be felt on passing the hand over the surface of the lung. It occasionally happens that all stages of development of the "secondary abscesses" may be observed in the same lung. The earliest stage is merely the effect of embolism. A small terminal artery having been obliterated by an embolus, the wedge-shaped portion of lung it supplies becomes intensely engorged with blood by regurgitation from the surrounding parts, or from the vessels of the pleura; the walls of the vessels soften and hæmorrhage into the lung tissue and air-vesicles takes place. The portion of the lung tissue then presents the ordinary appearance of so-called pulmonary apoplexy; it is dark red on section, like damson-cheese, airless and solid, but breaking down readily on pressure. The consolidated portion is spoken of as a "*hæmor-*

rhagic infarct." If this were due to the lodgment of an unirritating embolus, the extravasated blood and the tissues which have been deprived of their blood-supply would gradually be absorbed, leaving a depressed cicatrix in the lung tissue. In pyæmia, however, the embolus is infective and intensely irritating; consequently the vessel in which it is lodged sloughs, and the mischief extending to the surrounding tissues, the whole infarct softens and breaks down. The products of this process soaking away into the surrounding lung tissue cause inflammation, with exudation into the air-vesicles identical in its pathological appearances with ordinary croupous pneumonia. Occasionally all these conditions may be recognized in one infarct. On making a section through it a grey or yellowish fluid may be seen in the centre; it is not pus, being produced by gangrenous softening of the central parts of the infarct. Round this is a zone of pulmonary apoplexy; then follows a paler solid area, having the ordinary appearances of pneumonic consolidation, and round this again a zone of hyperæmia, in which the vesicles still contain air. As the area of softening extends, the cavity becomes a true abscess, containing pus mixed with the *débris* of the tissues of the lung, and the wedge-shaped form is then lost. The size of these abscesses varies greatly, from less than that of a pea to two or three inches in diameter. The pleurisy which accompanies, and in most cases results from, the formation of the abscesses is often very severe. The pleural surface is thickly covered with patches of inflammatory lymph, whilst quantities of deeply coloured turbid fluid are usually collected into the pleural sac. Sometimes, though rarely, small collections of pus are found scattered through the substance of the organ without affecting its pleural surface, or giving rise to any of the wedge-shaped masses above described.

The **Liver** frequently presents no abnormal appearances, even in severe cases, where the lungs have suffered most markedly; in others, again, it is the seat of many abscesses, which often attain a very large size. These have much the same character, both as to form and position, as those in the lungs, and are usually surrounded by a zone of hæmorrhage and congestion. When, however, they occur without any deposits in the lungs preceding them, they may appear as simple collections of pus, having a more or less branched arrangement. The form of pyæmic abscess does not appear to be the result of arterial embolism. In cases in which the general blood-poisoning is more marked than the local effects, the liver is found to be swollen, its structure is soft and more friable than usual, and its colour uniform and muddy. The epithelium is found on microscopic examination to be excessively granular.

The **Spleen** is usually large, soft, very friable, and often of an almost pulpy consistence. Infarcts unconnected with the pyæmic state are frequently met with in this organ; metastatic abscesses are not, however, very common.

The **Kidneys** are almost invariably swollen and soft; the epithelium cloudy, excessively granular, and often choking the tubules in irregular masses. They are very frequently congested, and sometimes the seat of abscesses presenting the same varieties as those found in other parts.

The **Intestines** rarely suffer, but abscesses may be found in the submucous or subserous areolar tissue. Local peritonitis not unfrequently follows the formation of hepatic abscesses, and may become very severe.

Of the other organs the **Brain** is most commonly affected. Diffuse suppura-

n is occasionally met with in the **parotid gland**, and in rare cases abscesses ve been observed in the **prostate.**

One or more **Joints** are frequently found to be swollen, and on opening em a large quantity of pale yellow or thick, flaky, and puriform fluid escapes. iere is congestion of the synovial fringes, with softening or destruction of e cartilage.

MICROSCOPIC APPEARANCES OF TISSUES AND ORGANS IN PYÆMIA.—ie blood in almost all cases contains a considerable excess of white, with leficiency of red corpuscles, but this condition is by no means peculiar to characteristic of pyæmia. The red corpuscles are usually unchanged; but, casionally, they have been observed to run together into irregular masses stead of forming rouleaux. Microscopic organisms have frequently been served in the blood, and these will be more fully referred to afterwards.

The yellowish fluid found in the veins as the result of softening of the rombi closely resembles pus in appearance, but on microscopic examination is found in many cases to be composed merely of granular *débris* containing true pus-cells. In other cases, as I have frequently observed, cells having e ordinary appearance of pus-cells are more or less abundantly present.

The so-called "secondary deposits" may in an early stage in like manner found not to contain pus, being composed merely of gangrenous tissue. In e later stages pus is always present.

The epithelium of the liver and kidney is usually granular and swollen.

Microscopic Organisms.—In almost all cases of pyæmia, micrococci can thout difficulty be recognized in various situations. Of these, the staphylo-ccus pyogenes aureus and the streptococcus pyogenes seem to be the most portant.

At *the seat of infection* they are frequently found in large quantities in the scharges, and in the slough that so frequently covers the surface of the ound. They are always present in the *fluid resulting from the softening of thrombi* in the veins. In the *blood* they are recognized with greater diffi-lty, and the evidence as to their presence has been very conflicting. iroughout all other parts of the body they have been observed *in the purulent uids in the secondary abscesses*, but their most characteristic appearance is as lonies or zooglæal masses blocking the *smaller arterioles or capillaries.* In is form they are readily recognized in sections prepared in the ordinary iy, and stained with logwood or methyl violet. They form rounded granular isses, in which it is often difficult to recognize the individual organisms cept at the edge of the mass. The vessel is slightly distended at the part which they are lodging, and a coagulum is occasionally seen above and low the obstruction. Sometimes the wall of the vessel appears to have ven way, and the organisms are found outside it. In most specimens no ange is observed in the tissues around the vessel, but occasionally inflam-itory exudation has taken place, and the group of micrococci seems to form e centre of a commencing abscess. These colonies of micrococci are found the lymphatic glands nearest to the seat of infection, in the liver, heart, yroid body, and with especial frequency in the tufts of vessels in the Malpighian dies of the kidney. The accompanying drawings (Figs. 347, 348, 349) pied from the Transactions of the Pathological Society of London, 1879, and om Koch's work on Infective Processes in Wounds, show very clearly the pearances presented by the micrococci in pyæmia.

General Pathology.—On contrasting the symptoms and the *post-mortem* appearances just described with those observed in the diseases experimentally produced in animals (see p. 968), it will be seen that they closely resemble, if they are not identical, with them. In those cases in which a softening thrombus is found in a vein, and the secondary abscesses in the lungs only, the conditions are identical with those obtained by injecting putrid matter containing coarse solid particles in suspension into the veins of an animal. In other cases the disseminated abscesses, with capillary thrombosis and the distribution of colonies of microscopic organisms throughout the system, closely resemble the results obtained by Koch from the injection of putrid fluids beneath the skin

Fig. 347.—A colony of micrococci lying amongst the muscular fibres of the heart. (From Path. Soc. Trans. 1879.)

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Fig. 348.—Colony of micrococci, from a lymphatic gland. (Path. Soc. Trans. 1879.)

In some rare cases the cavity of a foul abscess may open directly into a large vein by ulceration of the wall.

In those cases in which decomposing discharges are pent up in a deep wound, the conditions are essentially analogous to those which exist when putrid fluids are injected beneath the skin, as in Koch's experiments.

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VARIETIES OF PYÆMIA.—In the preceding pages a description has been given of the general symptoms and *post-mortem* appearances of pyæmia. The

Fig. 349.—Micrococci, plugging a small branching arteriole in the muscular fibre of the heart. The tissues around are infiltrated with inflammatory exudation. (Koch.)

disease, however, does not always run the same course, and a few definite varieties may be mentioned.

Acute Pyæmia.—In this form the rigors are well marked, the fever is high, secondary abscesses form early, and almost invariably affect the viscera ; death takes place usually before the tenth day. Acute pyæmia is found after death to be almost constantly associated with softening thrombi in the veins, and embolic abscesses. It is most common after operations or injuries involving the bones, as amputations or compound fractures, and is frequently preceded by septic osteomyelitis. It is invariably fatal. The part taken by embolism in the production of the secondary abscesses is often so evident in this form that it has been described as *embolic pyæmia*.

Chronic Pyæmia.—In this form of the disease the fever is less intense ; there may be but a single rigor, but occasionally it may be repeated frequently throughout the case. The secondary inflammations affect chiefly the subcutaneous cellular tissue and the joints, and occasionally the pleura, the viscera not being affected. Sometimes the secondary abscesses appear at points ex-

posed to pressure, as the shoulders, the elbows, or the back; in other cases suppuration takes place in subcutaneous injuries, as bruises or simple fractures. The patient may linger on for weeks, and finally die of exhaustion; or recovery may take place, leaving him in shattered health, with perhaps one or more joints firmly ankylosed. Chronic pyæmia is most frequently met with after injuries of the soft parts, especially the genito-urinary organs, and it constitutes a not uncommon form of puerperal fever. It has been known to follow gonorrhœa, and is allied to some forms of "gonorrhœal rheumatism." Should the patient die, as a rule no softening thrombi are found in the veins.

Umbilical Pyæmia is a name which has sometimes been given to a form of the disease occurring in infants from thrombosis of the umbilical vein, with subsequent softening of the clot.

Pyæmia without an Open Wound.—This may occur as the result of ulcerations of the alimentary canal, as in typhoid fever or dysentery, or as a consequence of some infective inflammation of a deep part. A general febrile disease with rigors and the formation of metastatic abscesses has also been observed as a complication of gonorrhœa. Perhaps the most common example of pyæmia from a subcutaneous inflammation is the form that so frequently follows acute necrosis of bones in children. This is an acute infective inflammation terminating rapidly in the formation of pus beneath the periosteum. It is very frequently complicated by thrombosis of the veins leading from the bone, and subsequent softening of the thrombi and embolism. The emboli are impregnated with the infective products of the local inflammation, and wherever they lodge they give rise to abscesses. The staphylococcus aureus (p. 243), is always found in these cases, and its presence has been demonstrated in the secondary abscesses as well as in the primary.

Idiopathic Pyæmia is a term applied to those rare cases in which the symptoms during life and the *post-mortem* appearances are those of pyæmia, and yet no local source of infection can be found.

Mixed forms of Pyæmia and Septicæmia.—Although these diseases have been described separately, it must not be supposed that they are always met with in actual practice distinct from each other. In most cases of pyæmia the patient suffers at the same time more or less severely from septic poisoning; the early blood-staining, the soft and swollen spleen, the subserous petechiæ, and the other characteristic signs of that condition form prominent features at the *post-mortem* examination. In other cases, with the exception of an unhealthy wound, a softening thrombus in the vein, and some softening infarcts in the lungs, the *post-mortem* appearances may be those of a healthy body. Between these extremes every variety may be met with. It is this that has led some Surgeons to the conclusion that septicæmia and pyæmia are mere modifications of a single process.

PROGNOSIS.—The prognosis in pyæmia is always bad. When active acute pyæmia has fairly set in, recovery rarely, if ever, takes place, the patient usually dying between the fourth and the twelfth days. One or two rigors may occur, and yet the patient may recover. Each repetition of the attack adds to the gravity of the case. In fact, the rapidity of the fatal termination in any given case will generally correspond to the frequency of the rigors and their severity.

When the pyæmic attack is from the first subacute or chronic, it may be recovered from, after prolonged illness, the formation of numerous or large abscesses, and great and continued disturbance of the general health. In

these less active and acute forms of pyæmia, the joints are specially liable to implication, more particularly the knee, and elbow. Destructive suppuration may be set up in the joint, and loss or permanent impairment of utility of the limb will be the inevitable result.

DIAGNOSIS.—The diagnosis of pyæmia requires to be made :—1, from ordinary Surgical Fever, the Inflammatory Fever which accompanies wounds and Injuries, and Typhoid Fever ; 2, from Ague ; 3, from Rheumatism ; 4, from Septicæmia.

1. The **Diagnosis from ordinary Surgical Inflammatory Fever and Typhoid Fever** is usually sufficiently easy, the course of these fevers being unbroken by severe rigors, by sudden fluctuations of temperature, or by sweats. An ordinary fever may be ushered in by a rigor ; but this is seldom so intense as that which marks pyæmia, and certainly does not recur during the attack. The temperature also in ordinary fevers is more uniform. It is not marked by those sudden exacerbations, followed by equally rapid declines, that are so characteristic of pyæmia.

2. From **Ague** the diagnosis would not be easy in the earlier stages, if the patient had been exposed to malarial influences, and was at the same time suffering from surgical fever resulting from a wound, as then the characteristic feature of intermittent fever, the prolonged period of normal temperature between the rigors, will be wanting. Thus in a person injured whilst living in a swampy country, there may be much doubt as to the nature of the attack ; but in large towns, the general absence of ague and the obvious surgical cause of the pyæmia will render the diagnosis more easy. In the later stages, the signs of articular inflammation and suppuration, the secondary visceral and areolar abscesses, will all tend to clear up the diagnosis. In any doubtful case a chart should be made of the temperature, when the regular periodicity of the attacks in ague will be very apparent if that disease is present.

3. From **Rheumatism** it is easy to make the diagnosis of pyæmia, provided the recurrent rigor and other early symptoms have been well marked. But if these have been somewhat obscure, and if the secondary articular implication be early developed, there may be some difficulty in determining the nature of the disease. But, independently of the recurrent rigor, the great prostration, the early supervention of atonic symptoms, and the local centres of suppuration, will establish the true nature of the disease. Moreover, the temperature of rheumatic fever does not show the extraordinary variations seen in pyæmia ; and the sweating in rheumatism is continuous, and not merely the sequence of a rigor. In pyæmia the tongue is usually dry, and perhaps brown, and never presents the creamy white fur characteristic of rheumatism. The smell of the patient is sweet or "saccharine" in pyæmia, while in rheumatism it is sour, and quite distinctive.

4. From **Septic Poisoning** and **Septic Infection** it is not always possible to make the diagnosis. In fact, as before stated, pyæmia is in the majority of cases more or less complicated by septic poisoning. In septic infection the acute symptoms, the single rigor, the marked signs of blood change, such as the icteric tint, the dyspnœa, and the early insensibility together with the absence of secondary inflammations, may serve to determine the nature of the case ; but in many cases the diagnosis is almost impossible during life.

TREATMENT.—The *Preventive Treatment* is *Local* and *General*.

The **Local Preventive Treatment** consists in preventing the accumula-

tion of decomposing discharges in the cavities of wounds or abscesses. This is carried out, first by properly draining the cavity in such a way that an accumulation of decomposable matter is impossible, and secondly by employing antiseptic agents in the dressing in such a way as to prevent even the slightest trace of putrefactive change in the discharges. It is evident that in many operations about the throat, rectum, and genito-urinary organs these principles cannot be fully carried out. In certain specific inflammations, as in infective endocarditis, or acute necrosis of bone, the inflammatory products possess infective properties independently of any contamination from the external air; and if they enter the blood-stream they may give rise to embolism of distant parts with softening of the infarcts and suppuration around them. Pyæmia cannot, therefore, be entirely banished from surgical practice, but it can be limited to a few exceptional cases. The experience of Lister, and of all Surgeons who have adopted the antiseptic treatment of wounds, has shown beyond a doubt that in all such cases as amputations, excisions of joints, recent compound fractures, removal of tumours, and the like, pyæmia can and should be entirely excluded, even in hospital practice.

The **General Means for the Prevention of Pyæmia** consist in a scrupulous attention to those hygienic measures which have been described in the earlier chapters of this work; and above all to a careful avoidance of *overcrowding*. Overcrowding is, however, a relative term. If, as must often happen in military practice, efficient antiseptic treatment is impossible, pyæmia is certain to break out if but a small number of patients are accumulated in a limited area; on the other hand if decomposition of the discharges can be prevented, a larger number may be treated in the same space without danger. No wise Surgeon would, however, on this account neglect the well-known laws as to cubic space, free ventilation, and general cleanliness, relying solely on antiseptics to prevent contamination of the air. It has already been pointed out in the early chapters of this work, that although putrid discharges are the most dangerous and most powerful source of contamination of the atmosphere of a surgical ward, the products of respiration and the accumulation of excreta will of themselves so vitiate the air as to impair the health and lower the vitality of those that breathe it; and thus delay the healing of wounds and favour the development of infective diseases.

A **Curative Treatment** of pyæmia can scarcely be said to exist. It doubtless happens that patients occasionally recover from this disease, even after the formation of diffuse abscesses; but such a result must be looked upon as a happy exception to its commonly fatal termination, rather than as the result of any special mode of treatment. The only treatment that holds out any hope of success appears to me to be the stimulating and tonic one, consisting of alcoholic stimulants, tonics, and liquid nourishment. I have certainly seen recovery follow, in some cases, the administration of large doses of quinine; five grains being given every third or fourth hour. Among many others, I may mention a very serious case of pyæmia following amputation of the arm, and accompanied not only by all the symptoms of that disease in a very marked degree but by pleuritic effusion, swelling and tenderness over one hip, and secondary hæmorrhage from the stump, which recovered under the tonic and stimulating plan of treatment. The quinine appears to check the rigors and to reduce the temperature. In some cases I have administered chlorate of potash largely (ʒ ij. to ʒ iv. in the day), in addition to the quinine and

wine, with apparent benefit. If the depression be very great, carbonate of ammonia in five or even ten grain doses may be given; such fluid nourishment as the patient will take, with a liberal allowance of alcohol, wine or porter, being also administered. In addition to this medicinal treatment, hygienic measures must be put in force. The patient should throughout be placed in an airy and well-ventilated apartment, and all hygienic rules carefully attended to.

As abscesses form, they must be freely opened. This should be done with antiseptic precautions, as the pus in the secondary abscesses is not in a state of putrefaction, and the patient's condition will be greatly aggravated if it be allowed to decompose. In cases arising as the consequence of septic osteomyelitis following amputations or compound fractures, removal of the limb at the next joint above the affected bone has been recommended and successfully practised by Joseph Fayrer, even after one or more well marked rigors.

If convalescence take place, the patient will recover slowly. The rigors and sweats will gradually become less frequent; the appetite will improve; the countenance will lose its anxious expression, and the skin its unhealthy hue. But strength returns slowly. The disease may assume a relapsing character. Great caution, therefore, is necessary before a patient can be pronounced safe. Even after recovery he will continue pale and wasted; energy is lost; nutrition is impaired; and at a more remote period some low form of disease, as phthisis or albuminuria, may prove fatal. These evils are best prevented by a course of sulphurous mineral water, followed by a long sea-voyage.

TETANUS.

Tetanus is an infective disease due to the presence of a specific virus in the body. It is characterized by painful and continued spasms of the voluntary muscles, alternating with incomplete relaxation, and it usually terminates fatally.

Causes of Tetanus.—The causes of tetanus are: first, the *essential cause*, the virus or contagium; and secondly, the *predisposing causes*, including such local and general conditions as predispose the patient to receive the virus.

The Essential Cause of tetanus is a small rod-shaped organism—the *Bacillus tetani*. This is rather longer than the bacillus of mouse septicæmia; spore formation takes place at one extremity of the rod and thus the organism assumes a characteristic "drum-stick" shape. The bacillus is anaërobic and its spores are very resistant to high temperatures.

The first evidence of the infective nature of tetanus was obtained in 1884 by Carle and Rattone from a patient who died of that disease originating from a suppurating acne pustule. They removed the inflamed area immediately after death, and having squeezed the fluid from it and diluted it with sterilized water injected the emulsion so prepared beneath the skin in twelve rabbits. Eleven of these died of undoubted tetanus. The blood of the dead animals failed to induce the disease when injected into others, but pieces of the sciatic nerve, into the sheath of which the emulsion had been introduced in four instances, were found, when crushed up in water and injected, to give rise to tetanus. In the same year Nicolaier, while making observations on the bacilli of earth, accidentally found that in a considerable

number of cases the subcutaneous injection of earth in rabbits, mice and guinea-pigs was followed by a fatal disease exactly resembling tetanus. Whenever this occurred there was present in the tissues, with other organisms, a fine and very small bacillus. Further observations showed that pus from the seat of inoculation produced the same disease in other animals, and contained the organism. It was subsequently cultivated on coagulated serum and inoculated with positive results. Dogs were not affected by the virus. In 1886 Rosenbach communicated a disease exactly resembling tetanus to rabbits by inoculating them with matter taken from the edge of the sore in a case of frost-bite, which terminated fatally from acute tetanus. In the diseased tissues he found, amongst other organisms, a very fine bacillus exactly resembling that described by Nicolaier. He obtained cultivations of this almost pure, being contaminated only by a septic bacillus which could not be separated, and with this cultivation he uniformly obtained positive results on inoculating rabbits.

Kitasato first obtained the bacillus in a pure state. Cultivations from the pus of a tetanic patient were made in an atmosphere of hydrogen, in which only anaërobic organisms could grow. By then exposing the mixed culture to a temperature of 80° C. the bacillus tetani which had already formed spores survived, whilst the other organisms with which the cultivation was contaminated were destroyed.

Predisposing Causes.—Tetanus is in the great majority of cases **Traumatic** in origin, and undoubtedly the most important local cause is the *presence of a wound*, by which the specific virus enters the body. From what has been said above it is clear that a wound contaminated with soil is especially liable to be infected, and thus the truth of the popular belief that tetanus is more likely to follow wounds of the hands and feet, and more especially of the ball of the thumb and of the great toe, can readily be understood. Although this may be true of the wounds common in civil life, the statistics of the American war show that wounds of the hands and feet are not more important in this respect than similarly contaminated wounds in other parts of the body. Of 505 cases, 21 followed wounds of the head or neck, 55 of the trunk, 137 of the upper extremity, and 292 of the lower. Of the 137 wounds of the upper limb which were followed by tetanus, 96 were above the wrist; and of the 292 of the lower extremity, only 57 were of the foot.

In the majority of cases the wound is punctured, contused or lacerated, more rarely incised. In one recorded case a man playing in a bowling-alley ran a splinter of wood under his finger nail; he died of tetanus, and fragments of wood from the floor gave fatal tetanus to mice when introduced beneath the skin. In another instance a boy wounded his foot in a playground and died of tetanus; earth from the playground produced tetanus in rabbits. The poisoned arrows of some savage tribes undoubtedly contain the virus of tetanus and cause death preceded by convulsions.

Tetanus in rare cases follows the clean-cut wounds made in surgical operations: thus, it has been known to follow removal of the breast, ovariotomy, amputation, ligature of the larger arteries, and the operation for hernia. The minor surgical operations also are not free from the possibility of this dangerous complication. It has been observed after the operation for fistula in ano, the ligature of piles and varicocele, and the removal of nasal polypi. I have seen a fatal case resulting even from the establishment of an issue; and burns are occasionally followed by tetanus. It has also been known to follow the

ligature of the umbilical cord in infants, and even the uterine irritation following abortion.

Tetanus may be occasioned by injuries that do not give rise to breach of surface: thus I have known it occur in a child which was suddenly thrown down upon its back by another at play, in a girl from a boy jumping on to her back, and in a lad by another striking him on the back by running a wheel-barrow at him; and Reid mentions a case produced by the stroke of a whip: but in the great majority of cases, it is directly occasioned by a *wound* of some kind.

It is also stated that the disease may arise from other causes besides injuries occasioning the **Idiopathic** form of tetanus: thus, for instance, it has been said to have been due to exposure to cold and wet.

Tetanus may occur at all *ages*, from the earliest infancy to an advanced period of life. In hot climates it is common amongst newly-born infants, in the form of *Trismus Neonatorum*. In this country it rarely occurs at this very early period of life, but is most common in young adults. I have most frequently observed it between the ages of 16 and 25, and after that in old people; but it may occur at any period of life. It is far more common amongst *males* than females—in the proportion of about four to one. *Season of the year* seems to exercise little influence over it. It occurs in all states of the atmosphere, and at all periods of the year; but is certainly most common when the weather is suddenly changeable—alternating from heat to cold. Indeed, long exposure to cold and wet, more particularly after the body has been heated, is said to be the most common cause of tetanus when it occurs independently of surgical injury, and is a frequent predisposing cause in persons who have been wounded.

Tetanus may occur in all *constitutions*; it is especially apt, however, to occur in feeble and debilitated individuals, and, indeed, may be looked upon as a disease of debility. When it occurs in persons who are otherwise strong and in the prime of life, it will usually be found that they have been exposed to causes of depression affecting the nervous system. In *tropical climates*, as in some of the West India Islands, and amongst the marshes of Cayenne, it occurs with peculiar frequency, and after the most trifling scratches or punctures. Poland states that the mortality from it is in London ·025 per cent., whereas in Bombay it causes 2·5 per cent. of the total deaths. It is interesting to observe, that the natives of hot climates are far more liable to this disease than Europeans resident there. In the American Civil War, 3·1 per cent. of the cases occurred amongst the negro troops, who furnished only 2·7 per cent. of the total number of wounds.

In *military practice* tetanus is of common occurrence. Its frequency varies much in different campaigns and under different circumstances, especially of season and climate. In the Peninsular War, it was estimated to occur in the proportion of about one case in every 200 wounded; in the Schleswig-Holstein War of 1849, according to Stromeyer, once in about 350 cases. In the Crimea it appears to have been of rare occurrence. In the American War it occurred in 0·2 per cent. of the wounded. After naval engagements, however, the mortality has often been high, more particularly in tropical climates. Gilbert Blane states that, after Rodney's action in the West Indies, out of 810 wounded 20 were attacked with tetanus, being one in 40. All European Army Surgeons are agreed that sudden changes from heat to

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covered and 69 died during the first day; 1 recovered and 83 died on the second day; 49 died on the third; 31 on the fourth; 22 on the fifth; 19 on the sixth; 14 on the seventh; and 7 on the eighth day. Thus of the acute cases 2, evidently slight in character, recovered; 294 died before the end of the eighth day; and in 203, or more than half, the disease did not exceed three days in duration. From the ninth to the nineteenth day inclusive, 36 died and 6 recovered; from the twentieth to the twenty-seventh inclusive, 7 died and 7 recovered; and 6 survived beyond the twenty-seventh day and finally recovered. The longest period during which the disease lasted was forty-nine days. These interesting statistics confirm the view that the more chronic the disease becomes the better is the chance of recovery; indeed, if the patient survive the tenth day, the prospect of a favourable issue to the case is materially increased. As a general rule, the danger is in the ratio of the acuteness of the attack, both as to severity and also as to rapidity of invasion after injury.

Rose has described a variety, which he called *Cephalic Tetanus*, resulting from wounds of the head, but more especially of the face. The most marked features of this form of the disease are facial paralysis on the same side as the injury, and marked pharyngeal and laryngeal spasm. On account of the latter symptoms the disease bears some resemblance to rabies, and it has therefore been called "hydrophobic tetanus."

Pathology.—Reference has already been made (p. 989) to the evidence that tetanus is produced by the action of a specific virus—the bacillus tetani. It is a fact of much importance that in cases following a wound the bacillus is not found in the blood, and further that it increases only to a very limited extent in the tissues of the damaged part.

It thus seemed probable that the symptoms of the disease were produced by a powerful poison absorbed into the blood from the focus of inoculation, and acting like strychnine upon the nervous system, especially the medulla and the upper part of the spinal cord. Vaillard and Vincent shewed that by filtering a pure culture of the bacillus they could obtain a liquid free from the organism itself, but which had the power of producing a typical fatal tetanus if inoculated into rabbits, guinea-pigs or mice. On the other hand, these observers found that inoculation of the bacillus purified from its products did not cause tetanus, and that under these circumstances the organism did not multiply at the seat of inoculation. When, however, earth containing the tetanus bacillus is inoculated, the organism multiplies locally and the absorption of the chemical products causes the typical symptoms. Vaillard and Vincent suggest that the difference is probably to be explained by the fact that in the latter case a mixed infection occurs, and that thus the tissues are in some way prepared for the growth of the specific organism by the other organisms which simultaneously enter them. Brieger has described four separate toxic substances which he obtained from cultures of the bacillus; the most important of these he called tetanin and tetano-toxine. It seems probable that the essential poison may be an albuminous body, allied to the soluble ferments.

Considerable success has attended the endeavours which have recently been made to produce immunity against tetanus in susceptible animals. Tizzoni and Cattani administered gradually increasing doses of a pure culture of the tetanus bacillus to dogs and horses until they could resist a large dose of the most virulent poison. The serum of the immunised animal was found

possess the remarkable properties of destroying the tetanus poison outside the body, and in some instances of conferring immunity on other susceptible animals. These properties were supposed to be due to an albuminous body—"tetanus antitoxine"—contained in the serum. Several cases have now been recorded in which injections of such serum appears to have arrested the disease in man after the onset of the first symptoms. In some of these cases, however, the disease was of the more chronic form, and we have already seen that in these the hope of recovery is much greater than in the acute form.

The Post-mortem Appearances to the naked eye are, apart from the local injury, most commonly those of a perfectly healthy body. Should the patient have died of asphyxia during a spasm, the distension of the right side of the heart, the engorgement of the lungs and the general venous congestion characteristic of that condition are present.

The microscope has shown evidences of inflammation in the nerves passing from the wound, and the theory that the disease is the result of an ascending neuritis was at one time suggested. In the majority of cases the changes in the nerve trunks are probably not more marked than those found in the immediate neighbourhood of any suppurating wound. In rare instances however more extensive neuritis has been met with, and Gowers suggests that this may possibly be of some importance in explaining those cases in which the spasms start from the seat of the injury.

The microscopic changes in the spinal cord in cases of tetanus have been studied by Lockhart Clarke, Dickinson, and Clifford Allbutt. Lockhart Clarke, in at least six cases, observed lesions of structure in the spinal cord, consisting of disintegration and softening of a portion of the grey substance of the cord, which appeared in certain parts to be in a state of solution. The fluid thus formed was in some parts granular, holding in suspension the fragments and particles of the disintegrated tissue, but in many places it was perfectly pellucid. He considers this due to hyperæmia of the cord, accompanied by exudation and disintegration. Dickinson has described intense hyperæmia with a structureless exudation poured out around the vessels in many parts of the grey matter, breaking down the surrounding tissue. He also observed some hæmorrhages in the white columns. These observations have been confirmed by Clifford Allbutt, but the exact significance of the changes observed is still uncertain.

Treatment.—The treatment of tetanus is local and constitutional. The **Local Treatment** has for its object to bring the wound into as healthy a state as possible, and to remove every source of irritation from it. In the light of our present knowledge of the nature of the disease the indications would seem to be—first, to lay open the wound to the full extent; secondly, freely to excise the tissues surrounding it; and thirdly, to apply some powerful antiseptic agent such as pure carbolic acid or chloride of zinc (40 grains to the ounce). Amputation has been recommended and has been followed by recovery in some of the more chronic forms of the disease, yet milder local means have sufficed equally well, and in the majority of cases it has had no effect; hence so severe an operation can scarcely be recommended for general adoption. Nerve section and nerve stretching have been practised in the belief that an ascending neuritis played an important part in the causation of the disease. As with every other of the score of remedies, local and constitutional, that have been employed for tetanus, recoveries have taken place after the

employment of these measures. On the other hand, in acute cases they have proved as impotent as the others.

In the **Constitutional Treatment** of the disease it is necessary to bear in mind that tetanus is an affection of debility, the violence of the spasmodic paroxysms giving an appearance of false strength to the patient; and that the principal source of danger and death is the exhaustion induced by the energy of the muscular movements. The means adopted should, therefore, have for their object the removal of irritation and the support of the patient's strength, so as to enable him to hold up against the disease.

Nothing can be more unsatisfactory than the treatment of the *Acute* form of traumatic tetanus. In it, all drugs are useless as curative agents, unless perhaps the antitoxine already mentioned (p. 995) prove an exception. Medicines may however act as palliatives, and afford relief to the patient; and much may be done by the Surgeon to mitigate his sufferings, and to place him in a favourable condition to withstand the exhaustion, and to lessen the torture of the spasms. With this view, the first thing to be done is to clear the bowels out well with an aperient dose; aided, if necessary, by a turpentine enema. The patient should then be kept perfectly quiet in a room by himself, a screen or muslin curtains, as recommended by Marshall Hall, being drawn round the bed, as noise or movement of any kind greatly increases the spasms. In order to allay the spinal irritation the most effectual plan is, perhaps, that recommended by Todd, of applying ice along the whole length of the spine: this is best done by a caoutchouc spine-bag. This is a powerful depressing agent, and care must be taken in its use. It may, however, be applied with safety for six or eight hours, the condition of the patient being carefully watched in the meanwhile. Sedative or antispasmodic agents are of no use whatever in acute traumatic tetanus. I have seen many drugs of this kind employed, without lessening in any degree the violence of the convulsions. In most cases, however, the inhalation of chloroform, or the administration of chloral, materially diminishes their severity, and gives the patient at least temporary ease.

In the *Subacute* or *Chronic* form of the disease, recovery is much more likely to take place; and it is only in these cases that antispasmodics and sedatives have been of use, and in these also chloroform and chloral are far more beneficial than in the acute cases. Almost every drug in the Pharmacopœia of a tonic, sedative, or antispasmodic nature has been employed in tetanus; and the recovery which has occasionally resulted has been perhaps over hastily attributed to the remedy, rather than to the employment of those dietetic and hygienic means which are of the first importance, by enabling the patient to live on until the disease wears itself out. Tonics, especially iron and quinine, have been employed by some. Elliotson was strongly impressed with the value of the carbonate of iron. Sedatives in all forms—conium, belladonna, opium, and their alkaloids—have been largely, and for the most part ineffectually, employed. Miller speaks highly of cannabis indica pushed to narcotism, three grains of the extract, or thirty minims of the tincture, being given every half hour or hour; and Haughton has employed nicotine in one-drop doses administered every second hour, with some apparent success in severe cases of traumatic tetanus.

The Calabar bean (*Physostigma*) is the remedy that perhaps deserves physiologically the most attention; for as it is nearly if not quite antagonistic

to the tetanic spasms of strychnia, it was hoped that it would be found equally useful as a sedative to the spinal cord in those arising from traumatic causes. In E. Watson's hands, very successful results followed its administration. Yet it is far from being a specific. I have tried it in several cases, with no appreciable good effect. It may be given by the mouth, hypodermically, or *per anum:* in the form of a solution or a tincture of the extract in half-grain doses, by the mouth; hypodermically, in doses of one-sixth of a grain; *per anum*, in grain doses. The dose should be given at least every second hour, until complete contraction of the pupil occurs. Stimulants, as brandy, should be administered to counteract the depression that will result from the use of the drug. At the same time that recourse is had to such measures as these, it must not be forgotten that the disease is one of great exhaustion, and that the patient will die worn out, unless he be supplied with plenty of nourishment. Beef-tea and wine should, therefore, be administered by the mouth, as long at the patient can swallow, and nutritious enemata by the rectum; and in this way the powers of life may be supported until the violence of the disease has spent itself. I am, however, disposed to think that even in these chronic cases, much more may be done by simple than by specific treatment. Clearing out the bowels by a turpentine enema, breaking the violence of the spasms and giving the patient rest and ease by chloroform inhalations or by chloral enemata, and keeping up the powers of the system by injections of beef-tea, egg, and brandy into the rectum, till the disease wears itself out, appear most likely to be followed by a satisfactory result, when used in addition to the hygienic measures recommended in the acute form of the disease.

CHAPTER XXXIV.

TUMOURS.

It is extremely difficult to give a short definition of the word Tumour, which shall cover all we mean by it and not extend beyond. According to Hunter, a tumour is "a circumscribed substance produced by disease, and different in its nature and consistence from the surrounding parts." Cornil and Ranvier define a tumour as a "mass composed of a tissue of new formation (a neoplasm) having a tendency to persist and to increase," and Lücke as "an increase in size from the growth of new tissue, which comes to no physiological termination." A tumour increases in size by an inherent force of its own, of the nature of which we are ignorant; and this is irrespective of the growth of the rest of the body, though the new tissue of which it is formed is developed by the same processes as those observed in normal growth. Although a tumour may closely resemble in structure the part in which it is growing, it can always be recognized by the naked eye if a section be carried through it, either by some slight difference in texture, or by its forming a clearly defined mass isolated from the surrounding structures. A tumour is distinguished from simple hypertrophy by the isolation of the growth and by the marked alteration in the form of the part to which it gives rise. In simple hypertrophy the new tissue is continuous with the old, identical with it in structure, and the general form of the part is maintained. Thus, if the great toe be uniformly enlarged in all its parts while maintaining the general form natural to it, the condition is termed hypertrophy, but a small outgrowth of bone from the ungual phalanx is a tumour. Inflammatory new growth is distinguished from a tumour by the fact that it takes place under the influence of some definite cause of irritation, and ceases at once if this be removed; the products of the inflammatory process are then absorbed more or less completely, any residue becoming developed into connective tissue. A tumour grows indefinitely, maintaining its original type of structure whatever size it may attain to, and is not dependent upon any evident source of irritation: in fact, should such arise, the tumour itself becomes inflamed. An inflammatory process is as a rule conservative in character, being concerned in some cases in repair of injury, in others in elimination of a virus, or the extrusion of a foreign body; the growth of a tumour serves no such purpose.

Classification of Tumours.—The only complete classification of tumours adopted at the present time is founded on their anatomical structure, but in addition to this, other less perfect divisions are employed for clinical purposes. Surgeons have long divided tumours into two great classes, the **simple** or **non-malignant** and the **malignant.** As a rule, this division corresponds accurately with that founded on the histological structure, and from microscopic examination of a tumour we can say with certainty whether it is simple or malignant. Thus some tumours, as the cancers, are always malignant, and others uniformly benign, as a fatty tumour. In others there may be some

doubt if the fully developed portion of the growth only be examined. Thus some cartilaginous tumours are as simple as a fatty tumour, and others as malignant as a cancer. These have been termed **semi-malignant**, but the name is not a good one. In the example above mentioned, the malignant cartilaginous tumours and the simple will be found to bear no resemblance to each other if carefully examined at their growing margins.

The **Non-Malignant, Innocent**, or **Benign Tumours** are strictly local growths, and are rarely connected with any hereditary peculiarity. They resemble more or less completely the normal textures of the part in which they grow. They usually, though not invariably, grow slowly, are more or less distinctly circumscribed, being often enclosed in a loose capsule of connective tissue, and have no tendency to involve neighbouring structures; any change that they induce in contiguous parts consists simply in displacement or atrophy from pressure. They are usually single, but not unfrequently multiple, developing either simultaneously or successively; but if in the latter mode, without any connection with preceding growths. If completely removed by operation, they do not return; but if left to the ordinary processes of nature, they slowly attain a great size, and at last the central parts degenerate or necrose, or if the tumour be superficial, the skin covering it ulcerates, and the mass inflames and sloughs. In some cases, after reaching a considerable size, they may remain stationary.

Malignant Tumours differ widely from those just described. The essential feature of malignancy is that the growth is not surrounded by any limiting capsule, but invades the structures amongst which it is growing, destroying them and occupying their place. The effect of the growth may not go beyond this, and the tumour would then be said to be merely *locally malignant.* In most malignant tumours, however, the effects are not merely local. Sooner or later the cell-elements of the tumour are carried through the lymphatics or the blood-vessels to distant parts, and there establish growths of the same nature as the primary tumour. The tumour is then said to possess **general** as well as **local malignancy**. A primary malignant tumour usually more or less closely resembles in structure the tissue in which it commenced. Thus, the essential feature of true cancers is the presence of epithelium in the new growth, and the form met with is always that normal to the part in which the tumour originated, as for instance, squamous in the tongue, columnar in the rectum, and spheroidal in the breast. In no malignant tumour does epithelium arise except from pre-existing epithelium. The malignant connective tissue tumours (sarcomata) show the same tendency. When they contain any fully developed connective tissue it is usually that normal to the part in which they are growing, as bone or cartilage in bone, or fibrous tissue in skin or fasciæ. Although, therefore, the structures composing malignant tumours are not, as was at one time supposed, foreign to the body, they deviate from the normal condition, so to speak, in time and place. The tissue of which the growth is composed is more or less approximated to the embryonic type normal to the part. Thus the malignant connective-tissue tumours are composed of embryonic tissue, sometimes pure, but more commonly showing a tendency towards development into the type normal to the part in which the tumour is growing. This is less marked in the true cancers which are, as a rule, composed of fully developed tissues, but even in these we often see the epithelium showing a tendency to return to the primitive rounded cell with a large nucleus,

and to lose the characteristics of the form in which it originated. Thus, in rapidly growing cancers of the tongue or rectum, the squamous or columnar cells may almost lose their special form. This reversion to the primitive type is not uncommon in the secondary tumours. In place, the deviation is most marked in the true cancers, in which we see epithelium penetrating deeply beneath the surface into parts where no such structure is normally present.

The following may be looked upon as the chief clinical and pathological characteristics of a malignant growth. The tumour, often at first circumscribed with a defined outline, soon invades the surrounding parts, and thus becomes fixed, moving, when manipulated, with the parts in which it lies, not in them. The rate of growth is, as a rule, rapid, but varies considerably. The vitality of the new tissue is usually low, and while its circumference is actively extending its central parts commonly undergo degenerative changes. When it reaches the surface it speedily sloughs, or ulcerates, giving rise to profuse discharge often offensive in character, and not unfrequently to abundant hæmorrhage. As its circumference continues to invade neighbouring parts a progressive destruction of the surrounding tissue takes place. At a variable period secondary growths make their appearance in different parts of the body. In the true cancers these appear first in the lymphatic glands, in some forms never going beyond these, in others subsequently extending to the viscera. In malignant connective-tissue tumours the glands often escape, the dissemination of the elements of the tumour taking place only through the blood-vessels, and the secondary growths appearing first in the viscera. When these have developed they serve as new foci for the dissemination of the disease, and usually assume a more active character than the primary affection. The patient now shows signs of serious modifications of nutrition. The body wastes, the skin becomes sallow, the digestive powers become impaired and anæmia supervenes; in short the patient develops the so-called *cancerous cachexia*. Most malignant tumours cause pain as they invade the surrounding parts, and, as a rule, they are more vascular than simple growths, and thus give rise to serious hæmorrhage when ulceration takes place. After removal they very commonly return locally, having infected the surrounding parts beyond the area removed. In other cases the patient escapes local recurrence, but perishes from the secondary growths. A malignant tumour if left to nature is inevitably fatal, from the exhaustion of the discharges or hæmorrhage, from implication of vital organs, or from the disturbance of health induced by the secondary tumours. Malignant growths are more commonly hereditary than simple tumours. The question of the local or constitutional origin of malignant growths will be discussed with cancers.

The term "*cancerous*" was at one time used as synonymous with *malignant*, but as our knowledge of the structure of tumours has increased, the large group of sarcomata has been separated from true cancers or carcinomata, and thus, though all cancerous tumours are malignant, all malignant tumours are not cancers. It is in this group of sarcomata that we find that less accurate correspondence between histological structure and clinical malignancy which gave rise to the use of the term "semi-malignant." Paget, for instance, observed that tumours apparently similar in structure may run a very different course in different individuals, in some being in every way innocent, and in others malignant. Thus a tumour, composed purely of spindle-shaped cells, may in

one case show no tendency to recur after removal, or to affect distant parts; whilst in another it may run a malignant course both locally and generally. The tumour would necessarily in both cases be classed under the same name in an anatomical classification. A careful investigation of the growing edge in the two cases would probably show that in the one case the tumour was growing in a capsule of areolar tissue, and in the other that this was wanting, and the new growth was distinctly invading the surrounding parts. Of the causes of this great difference in apparently similar growths we know nothing. In the cartilaginous tumours, which are sometimes given as typical examples of this uncertainty, the similarity of the malignant and simple forms is more apparent than real. In the malignant forms the cartilage will be found to be developed from a surrounding zone of embryonic tissue infiltrating the neighbouring structures. In the simple form the new cartilage is merely covered with a perichondrium, as in the normal cartilage of a growing bone. The former is a chondrifying sarcoma, the latter a true chondroma.

Even in undoubtedly malignant growths, as in carcinomata, we find the degree of malignancy very various in different cases without our being in any way able to account for it, either by the structure of the growth or by any peculiarity in the patient. Thus one man may die from secondary disease of the glands after a primary cancer in the tongue no bigger than a split pea, and another may show no glandular infection when half the tongue is destroyed. In other cases the malignancy may be from beginning to end local. This is the case in the disease known as rodent cancer. Some sarcomata recur locally, but after repeated removal the tendency may disappear and the patient eventually recover.

Innocent and malignant tumours are occasionally met with in the same person, four or five different kinds of growth even occurring in one individual. I have seen in one patient a carcinoma of the breast, an enchondromatous tumour of the leg, and an atheromatous cyst on the back, with scrofulous glands in the neck. New formations of different types may be found even in the same mass; thus, encephaloid carcinoma and spindle-celled sarcoma have been found together in the testis. This, however, must not be taken as any evidence of the possibility of the conversion of one into the other, but rather as the result of a departure in different directions from the normal mode of growth. There is indeed no proof that a non-malignant can be converted into a malignant tumour of a different type; a fibrous tumour may take on rapid growth and assume the characters of a malignant sarcoma, but there is no evidence that it can ever be changed into a carcinoma. A malignant tumour may, however, appear on the site of a non-malignant growth that has been removed: thus I have seen a scirrhous nodule grow in the cicatrix left after the removal of a cystic sarcoma of the breast. Warts and moles may exist for years without causing trouble, but at last may rapidly grow and develop either into malignant sarcomata or squamous carcinomata.

A **classification founded upon an anatomical basis** not only enables the observer to comprehend the precise relation which any particular growth under observation bears to others that resemble it, but leads him to trace the origin of the new formation from the pre-existing structures of the part in which it occurs, thus forming the first step towards a knowledge of the etiology of the disease. Tumours are said to be *heterologous* or *homologous*, according as they present a greater or less deviation from the normal condition

of the tissues from which they spring. These terms are essentially relative; and it is only to instances at the extreme ends of the series that either term can be definitely applied. At the same time it must be borne in mind that Virchow's law holds good even for the most heterologous growths; this law states, that "the same types of anatomical structures exist in new formations as are found in the body generally," and he thereby denies the possibility of the occurrence of a true heteroplasia, and the existence in new formations of specific elements differing from any normal cells in the body. The more heterologous the growth—that is, the greater the departure from the normal structure of the part in which it occurs—the more malignant, as a rule, will it be; whilst the reverse, with some exceptions, is true of homologous formations.

In classifying tumours according to their anatomical structure, they are divided primarily into four chief groups. First, those composed of one of the forms of connective tissue; secondly, those composed of tissue resembling one of the higher tissues of the body; thirdly, those composed of embryonic tissue, either pure or developing into connective tissue; and fourthly, those in which epithelium forms the essential part of the growth. Cystic tumours are classed by themselves, forming a fifth group.

General Characters of Typical Tissues.—Before proceeding to consider the individual growths, it will be desirable to describe briefly the essential features presented by the structures upon which the types of some of the classes are founded.

First as to **connective tissue**:—This exists throughout the body, presenting many varieties of form adapted to the special functions of the part in which it appears. It consists essentially of an intercellular substance, homogeneous, hyaline or fibrillated, in which are imbedded cells having an oval, caudate, fusiform, or branched form, and usually presenting a distinct central nucleus and nucleolus. In addition to these, in fibrous or areolar tissue, wandering cells, with amœboid movements, are normally present. These are regarded as white corpuscles, which have migrated from the vessels. The fixed connective-tissue corpuscle was looked upon by Virchow and his followers as the starting-point from which are derived the various cell-structures, entering into the formation of all tumours. Other pathologists have believed that connective-tissue tumours might arise by the growth and development of leucocytes which have migrated into the affected part. At the present time, whatever part may be ascribed to leucocytes in the formation of new tissue as a consequence of inflammation, they are not supposed to take any share in the growth of tumours of the connective tissue type.

The following are the chief forms of connective tissue: areolar tissue, adipose tissue, white fibrous tissue, yellow elastic tissue, bone, and cartilage. Mucous tissue must also be included under the same type. It is met with as the Whartonian jelly of the umbilical cord, and in the adult only as the vitreous humour of the eye.

The simplest form of **embryonic tissue** is composed of small round cells about the size of white blood corpuscles, connected with each other by a small quantity of homogeneous intercellular substance. The cell consists merely of a small mass of protoplasm with a nucleus in the centre, which may be somewhat difficult to distinguish. The vessels in such tissue are abundant, and extremely thin-walled, like those of granulations. The modifications

in this tissue observable in tumours are seen both in the cells and in the intercellular substance. The cells may be of great size, almost resembling epithelial cells with a large oval vesicular nucleus: they may be spindle-shaped, oval, or stellate. The intercellular substance may be small in quantity and homogeneous, or it may be increased in amount without apparent change in its nature. The most common modification is a development of fibrous tissue between the cells. In other cases it may be developed into bone or cartilage. It must be remembered, however, that in tumours classified under the type of embryonic tissue, with rare exceptions, a recognizable intercellular substance, either homogeneous or fibrous, extends between the individual cells, and this serves as an important point of distinction between some modifications of embryonic tissue and epithelium.

Epithelium is composed of cells united together by a homogeneous material or cement, which is not sufficient in quantity to be recognizable under ordinary circumstances. No vessels ever penetrate amongst the cells, nor do the fibres of the surrounding or subjacent connective tissue extend between the individual elements. Consequently if, on washing a microscopic section so as to remove the cells, a reticulate fibrous stroma is seen forming spaces in which single cells have lain, the tissue is not epithelial. It will be seen hereafter that some forms of tumour, composed of one of the modifications of embryonic tissue, may so closely resemble epithelial growths that it is only by carefully observing a washed specimen that the distinction can be made. Epithelium cells vary much in shape and size, and their outline is sharply defined. They possess usually one nucleus, sometimes two, with one or more highly refracting nucleoli. The nucleus is frequently eccentric. The form of epithelium met with in a primary tumour is always similar to that normal to the part in which the tumour is growing: thus in the skin it is squamous, in the intestines columnar, and in glands it is spheroidal. In secondary tumours, the type of epithelium corresponds to that of the primary growth. Primary tumours containing epithelium never originate except in connection with parts in which epithelial cells are normally present. This fact has led to another classification, according to the origin of the part in which the tumour grows, from one or other of the three layers into which the blastoderm divides in the first stages of development. From the superficial layer or epiblast are developed the central nervous system, the organs of sense and the cuticular covering of the body, and the glands of the skin; from the lower layer or hypoblast arise the epithelial lining of the air-passages, and of the alimentary canal with the epithelial lining of ducts opening into it, and the special epithelium of the glands themselves. The rest of the body arises from the middle layer or mesoblast. It is supposed that, after this early differentiation of the embryonic cells, the tissues which belong to one layer can never be developed from the cells of another. Thus tumours such as carcinomata, in which epithelium forms the active and essential element, can never develop primarily in those parts which arise from the mesoblast. Tumours have, therefore, been classified as epiblastic, mesoblastic, and hypoblastic.

The following classification may be adopted as possessing clinical convenience, and, at the same time, presenting, as far as possible, an anatomical uniformity.

I. Cystic Tumours generally.

II. Tumours composed of one of the modifications of fully developed Connective Tissue.

a. Fat—Lipoma.
b. Fibrous Tissue—Fibroma.
c. Cartilage—Chondroma, Enchondroma.
d. Bone—Osteoma, Exostosis.
e. Mucous Tissue of Umbilical Cord or Vitreous Humour—Myxoma.

III. Tumours which resemble in structure more or less perfectly one of the more Complex Tissues of the body.

a. Muscle—Myoma.
b. Nerve—True Neuroma.
c. Blood-vessels—Angioma, Hæmangioma, Nævus.
d. Lymphatic Vessels—Lymphangioma, Lymphatic Nævus.
e. Lymphatic Glands—Lymphadenoma.
f. Papillæ of Skin or Mucous Membrane—Papilloma.
g. Secreting Glands—Adenoma.

IV. Tumours composed of Tissue which is either purely Embryonic, or is showing some signs of a tendency to develop into adult tissue of the Connective type.

Sarcomata.—These are subdivided first, according to the shape and size of the cells of which they are composed, into round-celled, oval-celled, spindle-celled, giant-celled sarcoma, &c.; and secondly, according to the development they may undergo, into fibrifying, chondrifying, ossifying sarcoma, &c.

V. Tumours composed of Cells of an Epithelial Type, arranged in spaces in a vascular stroma consisting of more or less perfectly developed fibrous tissue.

Carcinomata or true Cancers.—Spheroidal or Glandular, Squamous and Columnar.

Etiology of Tumours.—In the great majority of cases we have not the remotest idea of the causes which have led to the growth of the tumour. Hereditary tendency has a marked influence in the growth of many forms, more especially of malignant growths. The cancers are certainly inherited in a large proportion of cases; in simple tumours hereditary tendency is less marked, but is occasionally to be traced. Paget also makes the very interesting practical remark, which agrees entirely with the result of my own observation, that the children of cancerous parents may be the subjects of tumours not carcinomatous in structure, but closely resembling such growths in the rapidity of their progress, their liability to ulcerate and to bleed, and their great disposition to return after removal. Local irritation or mechanical injury is undoubtedly the determining cause of the growth of the tumour in a certain proportion of cases. The effects of this cause are also most marked in malignant growths. The proportion, however, in which such a cause can be traced is very small, varying, according to different authors, from 7 to 14 per cent. Cohnheim has suggested the hypothesis that some tumours may arise from the minute portions of embryonic tissue which have persisted in an undeveloped state amongst the mature tissues; but there is little definite evidence to support this theory.

CYSTIC TUMOURS.

A **Cyst** is defined as a cavity of new formation, or resulting from the abnormal distension of a natural space, surrounded by a more or less distinct

wall, and filled with fluid or semi-solid matter. The wall of a cyst is lined by epithelium or endothelium, or has no definite lining, according to its origin. The accurate classification of cysts is difficult, because conditions which are pathologically similar are clinically spoken of as cysts in some parts of the body and not in others. The method usually adopted is that in which they are divided according to their mode of origin, as follows :—

1. Cysts arising from the distension of pre-existing spaces.
2. Cysts of new formation.
3. Congenital cysts.
4. Parasitic cysts.

1. Cysts arising from the distension of pre-existing spaces.—These are subdivided into : (*a.*) Exudation cysts ; and (*b.*) Retention cysts.

(*a.*) **Exudation Cysts** arise from chronic exudation into cavities which are not provided with excretory ducts, as, for instance, the bursæ, which often attain a considerable size in these circumstances. Strictly speaking, chronic synovitis, with "dropsy of the joint," hydrocele of the tunica vaginalis, and spina bifida, should be included in this class, but clinically these affections are never spoken of as cysts. A form of exudation cyst is sometimes met with in connection with serous and synovial membranes, which arises from a hernial projection of the membrane with subsequent constriction and obliteration of the neck of the protrusion, so that a separate cyst is formed. Some of the cysts met with in the popliteal space, and some of those formed in connection with the sheaths of tendons, or *ganglia*, are supposed to be formed in this way. Similar cysts are occasionally met with in one of the situations of abdominal hernia, which are evidently formed by the obliteration of the neck of the sac of the peritoneum, with subsequent exudation into the closed cavity.

In cysts formed in connection with synovial membranes or bursæ, opaque, white, or yellowish bodies, resembling melon seeds in size and form, are not unfrequently met with. Sometimes these are attached to the cyst-wall by a narrow pedicle, but more often they are free. They are supposed to arise in three ways : first, as an outgrowth from the cyst-wall ; secondly, by changes taking place in extravasated blood ; and lastly, from a fibrinous exudation from the wall of the cyst. The presence of blood-crystals, which has been recognized in some cases, proves that they occasionally arise in the second way. The symptoms and treatment of these affections are described with diseases of bursæ (see Vol. II.).

One form of *cystic disease of the ovary* may be placed under this head, as it arises from dilatation of the Graafian follicles. The cysts are usually numerous, but do not individually reach any very great size. They contain a serous fluid, and ova have been recognized within them, thus proving their origin.

(*b.*)—**Retention Cysts** arise from an obstruction to the escape of some natural secretion, in consequence of which the acini, or tubules, of the gland become expanded, or the duct becomes dilated to such an extent as to form a distinct cyst. The process by which the cyst is formed is not one of simple dilatation ; it is accompanied by a new growth of fibroid tissue, resulting from the irritation caused by the tension of the retained secretion, so that in almost all cases the wall of the fully developed cyst is many times thicker than the structure from which it originated. If the cyst springs from a duct, the walls of which contain involuntary muscular fibre, this will be found to have disappeared, the new tissue being purely fibrous. The cyst-wall is lined with

epithelium of the same character as that naturally lining the cavity from which it has originated. The contents may still resemble the natural secretion, but more commonly they are altered by degeneration and inspissation, or by exudation from the wall of the cyst.

Retention cysts may be divided into three groups: (*a.*) Atheromatous cysts; (*β.*) Mucous cysts; and (*γ.*) Cysts from the dilatation of large ducts. The first two groups are spoken of as "follicular cysts."

(*a.*) **Atheromatous Cysts** are those arising in connection with the sebaceous glands of the skin. They are usually situated upon the scalp, face, neck, or back; sometimes, however, they occur elsewhere—thus I have removed a very large one from the fore part of a girl's arm, and others from the labia and groin. Their size varies from that of a pin's head to an orange: the smallest occur on the eyelids, the largest on the shoulders and scalp.

Fig. 350.—Contents of Atheromatous Cyst (454 diam.).
a. Epithelial cells showing various degrees of fatty degeneration.
b. The same with calcareous degeneration.
c. Crystals of cholesterine.
d. Oleaginous and fatty particles.

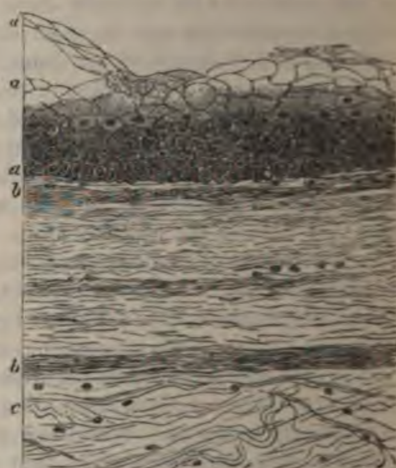

Fig. 351.—Wall of Atheromatous Cyst (188 diam.)
aa. Epithelial lining, the superficial cells swollen and fatty.
a'. A flake of fatty cells peeling off.
bb. Fibrous capsule.
c. Surrounding connective tissue.

Atheromatous cysts are often very numerous, especially about the head. Most frequently they form in women about the middle period of life; they are smooth, round, or oval, usually adherent to the skin at one spot but movable over the deeper structures, either semi-fluctuating or elastic, though sometimes solid to the touch. In some parts where the sebaceous follicles are large, as on the back, a small black point can often be detected on the surface of the tumour, through which an aperture may be found leading into its interior, and allowing the expulsion of its contents. A sebaceous tumour consists of a cyst-wall and contents. The cyst-wall is composed of dense white fibrous tissue, having elongated connective-tissue corpuscles scattered through it. It is connected to the surrounding parts by loose areolar tissue, containing yellow elastic fibres in some abundance. The thickness of the wall varies greatly. When the cyst is situated on the hairy scalp it is always tough and thick, while in all other situations it is much thinner. Immediately in contact with the inner surface of the cyst-wall, a layer of actively growing

epithelial cells is found closely resembling the deeper layers of the epidermis; further from the wall these assume a more flattened form; then they become filled with fat granules, and finally break down into a fatty granular mass (Fig. 351). The atheromatous mass forming the contents of the cyst is composed of this fatty *débris*. If examined when freshly removed from a tumour, it will be found to be soft, creamy, pultaceous, or sometimes cheesy-looking, of a yellowish white colour. Sometimes in old cysts it becomes dry and laminated, looking not unlike Parmesan cheese. In some cysts of old standing and large size, the contents may be semi-fluid, the more liquid parts being of a brown, green, or blackish tint, and having a very offensive sour smell. These various contents are composed of sebaceous matter, mixed in various proportions with epithelial scales, fat granules, and cholesterine (Fig. 350). Sometimes the wall sends fibrous septa towards the centre of the cyst, apparently representing the remains of the tissue between the acini of the follicle; but true papillæ or hair-follicles are never found in cysts due to obstruction of the excretory ducts of a sebaceous follicle. Occasionally a part of the cyst-wall may undergo calcification, and calcareous particles may be found among its contents (Fig. 350 *b*). Malherbe has described a true ossification of the cyst-wall with calcification of the epithelium cells. This is rare, and the tumours have been described as osteomata of the skin before their true nature was understood. Some forms of cysts of new formation closely resemble those just described in their contents and naked-eye appearances, but differ from them in the structure of their walls, which is that of true skin. These will be referred to again under "dermoid cysts."

Progress.—The growth of these tumours is often very slow; but not unfrequently, after remaining stationary for years, they increase rather rapidly. The tumour itself, though painless, may give rise to uneasy sensations, by compressing nerves in its vicinity; it usually continues to grow slowly, until the patient, being annoyed by its presence, has it removed by operation. If left untouched, it occasionally, though rarely, happens that the sebaceous matter, exuding through an aperture on its surface, forms a kind of scab or crust, which by a process of sub-deposition becomes conical; and, being gradually pushed up from below, at the same time that it assumes by exposure a dark brown colour, forms an excrescence that looks like a horn, and is usually considered to be of that character. These "horns" have been met with on the head, on the buttock, and in other situations. The accompanying drawing (Fig. 352), is taken from a child four years old, brought to me to have its horn removed; a woman also once applied to me with one about an inch and a half long, growing from the upper lip.

In other cases, these tumours inflame and suppurate; the skin covering them becomes adherent and reddened, ulceration takes places, and, if the cyst be small and dense, it may be destroyed by suppuration around it. If it be larger, ulceration of the integuments covering it takes place, and the sebaceous matter is exposed; this may then putrefy, become horribly offensive, and break away in unhealthy suppuration. In other cases, peculiar changes take place in the cyst-wall: large granulations are thrown out in it, and the cyst-wall appears to vascularize, becoming irregular and nodulated, rising up in tuberous growths with everted edges, exuding a fœtid discharge, becoming adherent to subjacent parts, and assuming a malignant appearance, forming at last a sore as large as a saucer (Fig. 353). Cysts that have undergone this

change show great local malignancy, rapidly infiltrating and destroying the surrounding parts, but as a rule the lymphatic glands are not implicated. I have seen a case in which the skin was destroyed from a little below the vertex to the root of the neck, and from ear to ear transversely. The surface was covered with fungating granulations, but there was no implication of the glands. Lücke states that in such cases a genuine transformation of the atheromatous cyst into a squamous carcinoma has taken place, the epithelium penetrating the cyst-wall and growing in the tissues beyond. It most commonly occurs after middle life.

Diagnosis. The only diseases with which these tumours can be confounded are abscesses and fatty growths. From an *abscess* a sebaceous cyst may be distinguished by its history, slow growth, situation, elasticity, and mobility, and if there should be present the dilated orifice of the sebaceous duct, through

Fig. 352.—Horn on Nose of a Child.

Fig. 353.—Ulcerated Cystic Tumour of Scalp.

which some of the contents can be squeezed, the microscopical examination of these will serve to confirm the diagnosis. From *fatty tumours* these growths may be diagnosed by their firmer and more regular feel; and in case of doubt, by the evacuation and examination of their contents. Sometimes the cysts may be lobulated so as closely to resemble a fatty tumour (Fig. 354). But even in these cases they may be distinguished by the Surgeon pressing on the edge of the tumour; if cystic it will remain fixed, and the finger can be pressed through it; if a lipoma it will roll away. When this cyst has become cancerous, its origin can be ascertained only from the history.

The *Treatment* of a tumour of this kind consists simply in its removal, after which it is never reproduced, unless a small portion of the cyst-wall has been left behind. So long as these tumours are small, and do not give rise to inconvenience, they may be left without surgical interference. But when large, and more particularly when they have become inflamed, they should be removed. The method of operation will vary according to the situation of the cyst and the thickness of its wall. When situated on the scalp, where the cyst is dense and tough, the tumour may very readily be removed by transfixing it and the skin covering it with a scalpel, squeezing out the contents, and then seizing the cyst-wall with forceps and pulling it out. In this little operation

there are two points that require attention : first, the base of the cyst should never be transfixed ; and, secondly, no attempt at dissection should be made. If either of these precautions be neglected, troublesome hæmorrhage may ensue. The hair should be cut away from the immediate neighbourhood of the tumours and the scalp thoroughly washed with soap and hot water and a dilute solution of ammonia. A towel soaked in 1 in 30 carbolic lotion should be applied for half an hour before the operation. The incisions should be sutured, and dressed with an efficient antiseptic dressing firmly applied with a capelline bandage. When situated about the face, back, trunk, or limbs, sebaceous cysts usually require to be dissected out, being thin and more closely incorporated with the skin; and often, in consequence of former inflammation, adherent to the subjacent parts. In doing this, care should be taken that the whole of the cyst-wall is extirpated. If, however, any portion of the wall be left, it should be freely rubbed with nitrate of silver, lest a troublesome fistula remain. When the tumours are situated between the shoulders or on the back, and the patient is unwilling to submit to an

Fig. 354.—Large Atheromatous Cyst from the Back, simulating Fatty Tumour. (Half the natural size.)

operation, I have sometimes cured them by opening up with a probe the small black orifice, which will always be found leading into them, squeezing out the contents of the cyst, and then pushing in two or three silk threads, which, acting like a seton, have excited the amount of inflammation requisite to bring about a closure of the cyst.

The horns and malignant ulcers that result from these growths require excision. If, however, the ulceration be connected with the cranium by its base, or be very extensive, as in the case depicted (Fig. 353), it may be impossible to remove it, and it will be safer to treat it by the application of the chloride of zinc, or by occasionally touching it with potassa fusa.

(β) **Mucous Cysts** arise in mucous membranes in the same way as atheromatous cysts in the skin. Their walls are usually thin, and, as a consequence, they seldom reach any great size. Their contents usually consist of a turbid viscid fluid, and cholesterine is sometimes present. They are most commonly met with in the mouth, and occasionally in the tongue. They form one variety of ranula; and the so-called dropsy of the antrum, is in most cases a mucous cyst developed within the cavity. They are also met with in the labia, arising from the glands of Bartholini, and Cowper's glands in the male are said occasionally to undergo a similar change. They are best treated by excising a piece of the wall and applying a strong solution of chloride of zinc to the interior of the cavity.

(γ) **Cysts arising from the dilatation of the ducts of glands** are less

common. They are met with in the mamma from obstruction of the lacteal ducts, in the mouth as ranula from obstruction of Wharton's duct, and in the testicle, forming the so-called encysted hydrocele or spermatocele. Cysts of similar origin are also met with in the liver and kidney. The consideration of the symptoms and treatment of these cysts must be deferred to the chapters on the diseases of the organs in which they occur.

II. Cysts of New Formation.—Cysts of new formation may be divided into (*a*) Simple or serous cysts ; (*b*) Hæmatoma or blood-cyst ; (*c*) Cystic tumours, compound and proliferous cysts ; (*d*) Cysts in tumours.

(*a*) **Simple or Serous Cysts** may occur in any part of the body. They are composed of a thin wall lined with a flat endothelium, like that of a serous or synovial membrane. Their contents are a slightly viscid serous fluid. They are supposed to arise from effusion of fluid in the spaces of the areolar tissue ; by the pressure of the fluid the surrounding fibres are squeezed together and thus form the membranous wall of the cyst, which subsequently becomes thickened by new growth of fibrous tissue.

False or Accidental Bursæ arise in this way over any bony prominence which is exposed to pressure and friction ; in fact there is some reason to believe that all bursæ are thus formed. Whether this be the case or not, false bursæ when once formed are liable to the same diseases as those that are usually assumed to be of normal development. The most common and troublesome false bursa is that formed over the projecting head of the first metatarsal bone which gives rise to the condition known as a "*bunion*."

It is probable that many of the tumours classed as "ganglia" are formed in the same way, especially those on the back of the hand, as the extensor tendons in that region do not possess a sheath sufficiently definite to allow of a hernial protrusion from it.

The serous cysts met with in the neck do not belong to this class. They are either congenital or formed by dilatation of pre-existing spaces, such as the bursæ about the hyoid bone or larynx.

(*b*.) **Hæmatoma or Blood-Cyst.**—Under this term have been included four entirely different conditions :—

(1.) The *true blood-cyst*. This is a thin-walled cyst containing pure blood ; if its contents are withdrawn by puncture it rapidly fills again, and cases have been recorded in which death from hæmorrhage has followed incisions made into such cysts. They are most common about the neck, in close connection with the sheaths of the vessels, or the parotid region ; but they have been met with elsewhere. Their origin is very doubtful. Some, from their multilocular form and direct communication with the veins are supposed to have originated in nævi. In others, the cyst is single, and has no connection with any distinct vessel ; the blood seems in these to be furnished by an extremely vascular cyst-wall, as in a case recorded by Gay. These sanguineous cysts may sometimes resemble in general appearance a soft vascular sarcoma. A case of this kind was sent to me by Henry Bennet : a tumour about the size of an orange, of nodulated appearance, was situated in the leg of a woman below the knee, where it had been gradually increasing in size for about a couple of years. So close was the resemblance to malignant disease, that amputation had been advised by some Surgeons who had previously seen the case ; as, however, the growth, on examination, proved to be a sanguineous cyst, with thin and adherent walls, and as it extended too deeply into the ham to admit of ready removal, I

reduced it by successive tappings, and then, laying it open, allowed it to granulate from the bottom. When practicable, however, the cyst should always be dissected out.

(2.) Many cases have been described as blood-cysts, which are in reality *serous cysts into which an accidental hæmorrhage has taken place.* In these, unless the hæmorrhage be very recent, the blood has undergone changes in colour from disintegration of the corpuscles. In some cases it is treacly from absorption of a part of the serum.

(3.) The term "hæmatoma" is more commonly applied to *cysts which have their origin in an extravasation of blood.* The changes that occur in extravasated blood have already been described (p. 312). In some cases, as there pointed out, absorption fails to take place. The extravasated blood distends the spaces of the areolar tissue, or fills a cavity formed by subcutaneous laceration. A deposit of fibrin first takes place, and subsequently, in consequence of the irritation caused by the tension of the fluid, an ill-defined capsule of fibrous tissue is formed round the extravasation. The contained blood becomes altered in colour from disintegration of the corpuscles, and finally the contents assume the appearance of more or less darkly-tinged serous fluid. The hæmatoma of the ear so frequently met with as the result of violence during the game of football, when played according to the Rugby rules, is a cyst of this kind. Similar cysts are not uncommonly met with in the ears of lunatics, and in these cases the cause is not so evident. I have seen a large hæmatoma on each ear of a lunatic. The contents consisted of semi-solid coagulum.

Similar cysts are occasionally found as a result of hæmorrhage into the subarachnoid space. The coagulated blood in the course of time becomes completely discoloured, and forms a thin membrane-like layer of tissue which encloses a cavity containing a small quantity of serous fluid.

(4.) In many cases which have lately been recorded, it has been found that tumours which were described clinically as blood-cysts were in reality *soft sarcomata*, the structure of which had been broken down by hæmorrhage. (See Sarcomatous Blood-cysts.)

(*c*.) **Cystic Tumours.**—These are tumours in which the development of cysts is an essential of their growth, and not merely an accidental complication. To this class belong the *compound* or *multilocular cysts* met with in the ovary, the mamma, and the testicle. In many cystic tumours solid growths project from the walls into the cavities, and from this they have received the name of *proliferous cysts;* the growths are spoken of as *intracystic growths.* Multilocular cysts, as met with in the ovary, form the best example of this form of tumour. These cysts are composed of a fibrous wall and an inner lining of columnar epithelium. Immediately beneath the epithelium is a layer of embryonic tissue, from which spring the intracystic growths. These assume the form of branched papillæ projecting into the cavity of the cyst; they are covered by columnar epithelium. Wilson Fox showed that secondary cysts may be formed by the adhesion of adjoining masses of this papillary growth, thus forming small closed spaces or daughter-cysts, which gradually become distended by secretion. In some cases the reverse process takes place, and instead of the number of cysts increasing by the formation of daughter-cysts, they become diminished by coalescence. Unilocular ovarian cysts are supposed to be often formed in this way. The contents of these cysts vary from a liquid as thin as ordinary blood-serum, to a viscid fluid. It is alkaline in

reaction and sometimes coloured from the admixture of altered blood. Chemically it is found to contain met-albumin and par-albumin, and sometimes mucin, from which it is assumed that the fluid is a true secretion, in the formation of which the epithelial lining is concerned.

In the proliferous cysts of the mamma the intracystic growths assume a lobulated or cauliflower-like form, and in structure are found rudely to resemble the normal structure of the mamma. These growths may, according to Paget, by their increase in size cause the gradual absorption of the more fluid contents, until, at last, their development is arrested by the cyst-wall. The tumour would then resemble an ordinary adenoma of the mamma surrounded by a distinct capsule.

The cystic tumours of the ovary, mamma, and testis, will be more fully described with the diseases of those organs.

(*d.*) **Cysts in Tumours** form, not as an essential part of the growth, but

Fig. 355.—Head and neck of an adult, with diagrammatic lines, representing the situation and direction of the branchial and other clefts. 1, 2, 3, 4, first, second, third, and fourth clefts; 5, intermaxillary cleft; 6, Fronto-orbital fissure; 7, naso-maxillary fissure.

as an accidental complication. They may arise from softening of portions of the growth, or from hæmorrhage into its structure. As a rule they are not surrounded by a distinct wall, but in some simple tumours they seem to increase by transudation of serum into the cavity, and thus the surrounding structure may be compressed so as to resemble a limiting membrane. Cartilaginous tumours occasionally become cystic from mucous softening of the matrix. Cysts in tumours will be more fully described with the growths in which they occur.

III. Congenital Cysts.—This class includes:—(*a.*) Cysts lined with skin or mucous membrane and resulting from inclusion of the epiblast within the mesoblast during development or more rarely from imperfect obliteration of some fœtal canal. These are Dermoid Cysts. (*b.*) Cysts arising from imperfectly obliterated temporary fœtal structures.

(*a.*) **Dermoid Cysts.**—The majority of these result from inclusion of a portion of the epiblast. Cysts thus formed are distinguished as "*sequestration dermoids*," by Bland Sutton, who has added much to our knowledge regarding this highly interesting class of cystic formations.

It will be remembered that in the very earliest stages of development the germinal membrane or blastoderm divides into three layers. From the most superficial of these, or epiblast, is developed the cuticular covering of the body, with the hairs and glands of the skin and the central nervous system; from the deepest layer, or hypoblast, arise the epithelial lining of the air-passages and of the alimentary canal and the epithelium of the glands connected with it; while the rest of the body is developed from the middle layer or mesoblast. The blastoderm is at first flat, but in the process of development it becomes folded on itself, and thus encloses the abdominal cavity; the mouth and neck are developed from lateral processes, the branchial arches, which curve downwards till they meet in the middle line, and between these arches are fissures, the branchial clefts. The lateral parts of the face are developed in the same way, while the nose and middle parts above the mouth arise from a descending process proceeding from the frontal region. By the coalescence of all these the face and throat are formed. It can easily be understood how in this process a portion of the epiblast may become included and remain imbedded in the tissues belonging to the deeper layer. Should this happen, a closed cyst may be formed lined internally with the structures proper to the skin, and yet entirely unconnected with it. Dermoid cysts are met with most commonly in the subcutaneous tissue in situations in which their position can be explained by the process of inclusion above described. The accompanying diagram, (Fig. 355) from a paper by Cusset, well illustrates the lines in the neck which correspond to the branchial clefts, and to the meeting of the various processes from which the face is developed in the fœtus. It is in these lines that dermoid cysts are most commonly met with. They are most often found at the upper and outer angle of the orbit. Here there is often an indentation in the bone corresponding to the cyst, and in some cases the bone may be wanting, the tumour being in direct contact with the membranes of the brain, a fact which it is important to remember in attempting their removal. They have occasionally been found within the skull on the meninges.

Fig. 356.—Wall of Dermoid cyst (40 diam.).
a. Epidermis.
b. Hair-follicle.
c. Sebaceous gland.
d. Surrounding connective tissue with small masses of fat.

On the trunk dermoid cysts are occasionally met with along the middle line where the opposite halves of the body wall join each other.

The walls of the superficial dermoid cysts present all the structures of true skin—cuticle, cutis vera, papillæ, sweat-glands, sebaceous follicles, hair-

follicles, and hair (Fig. 356). Their contents are usually rather thinner than those of the ordinary atheromatous cyst, though closely resembling them in appearance. Often a small ball of coiled-up hair is found inside the cavity. The contents are the accumulated secretions of the glands in the cyst-wall mixed with desquamated epithelium.

It is interesting to note that cysts lined with epidermis are occasionally met with on the fingers or elsewhere as the result of punctured wounds. In such cases the epithelium from which the cyst formed has been driven into the subcutaneous tissue by the instrument inflicting the injury.

Those rarer forms of dermoid cysts which develop from an embryonic canal which fails to undergo the normal process of obliteration are distinguished by Bland Sutton as "*tubulo-dermoids.*" A well-known example is the dermoid cyst which occasionally forms beneath the tongue in the middle line of the floor of mouth. This cyst, in some cases at least, is developed from the thyreo-lingual duct or canal of His, which passes from the foramen cæcum at the back of the tongue downwards behind the hyoid bone to the isthmus of the thyroid body. Normally this duct becomes completely obliterated, but should the closure fail in that part which lies above the hyoid bone a sublingual dermoid cyst may result. To the same class belong those dermoid cysts which occasionally occur in the neck beneath the deep cervical fascia at the anterior border of the sterno-mastoid, and arise in a deep unobliterated portion of one of the branchial clefts. Dermoid cysts of this class may or may not contain sebaceous glands in their wall, and accordingly the contents may consist of the usual sebaceous matter or of clear fluid.

Dermoids of the ovary are remarkable from the complex nature of the structures often present in their walls. Among these may be mentioned bone, teeth, cartilage, &c., whilst in two remarkable specimens a mammary gland projected into the interior of the cyst ; one of these recorded by Bland Sutton is preserved in the Museum of the Middlesex Hospital. Ovarian dermoids may gradually contract adhesions to the omentum or mesentery and lose their connection with the ovary itself.

(*b*) **Congenital Cysts arising in Imperfectly Obliterated Fœtal Structures.**—Certain dermoid cysts already described arise in this way, but the cysts included in this class differ from them in possessing no lining of skin or mucous membrane. To this variety may be referred the cysts of the spermatic cord which arise from the distension of a portion of the processus vaginalis testis which has remained unobliterated, although cut off from the cavity of the peritoneum above and the tunica vaginalis below.

Some tumours of the testicle and some growths arising in the neighbourhood of the kidney which contain large cysts lined with columnar epithelium are supposed to arise from the unobliterated remains of the Wolffian body ; and the parovarian cysts arising in the broad ligament of the uterus have the same origin.

A rare form of congenital tumour known as a **teratoma** may conveniently be mentioned here. It consists of a complicated mass of various tissues and organs, which is adherent to or included within the body of an otherwise perfectly developed fœtus. Certain congenital tumours of the sacral region are supposed to be of this nature.

(5.) **Parasitic Cysts.**—Cysts occasionally come under the care of the Surgeon which owe their origin to the presence of a *parasite.* The most

common of these is the **hydatid cyst**, which, although somewhat rare in this country, is extremely common in Australia. The parasite is met with in its fully developed state only in the wolf and dog. It is a small tapeworm about $\frac{1}{8}$ inch in length, the tænia echinococcus, consisting of four segments or proglottides, the last of which is the largest, and contains the ova. The latter usually find their way into the human subject in water or in food contaminated by the excrement of the dog. On entering the human intestine, the small embryo contained in the egg is set free, and by means of a boring apparatus with which it is provided, penetrates the wall of the gut. It is then carried by the blood-stream to some distant part, in which it develops into a cyst or hydatid. The hydatid cyst is composed of an outer cuticular layer and an inner granular lining composed of cells, muscular fibres, and a water vascular system. The contents of the cyst consist of a clear fluid of very low specific gravity, usually not over 1007, and containing either no albumen or the faintest possible trace, with a considerable quantity of sodium chloride. The cyst-wall to the naked eye appears as a delicate, semi-transparent, elastic membrane not unlike the white of a hard-boiled plover's egg. It is seldom more than one-eighth of an inch in thickness, and can be seen by the naked eye to be laminated, and a still finer lamination is recognized under the microscope. On the inner surface of this membrane the tænia heads or scolices are formed by a development from the living tissue lining the cyst. The head is a small round dot, just recognisable to the naked eye, and about $\frac{1}{100}$ inch in diameter. It is provided with four suckers and a ring of hooklets, which are generally seen retracted into the middle of the head (Fig. 357). If the hydatid perishes, these heads break up, but the hooklets being indestructible, can usually be detected in the fluid. The cyst may be single, but very commonly "daughter cysts" are formed from the wall of the parent cyst, and become free in the cavity or outside it. The parasite is not capable of further development in man, and it is only by a migration in some way again to the dog or wolf that it can reach the stage of the fully developed tænia. The size to which the cyst may attain is sometimes enormous, as much as five pints of fluid having often been removed. The irritation set up by the cyst causes a development of fibrous tissue in the structures surrounding it, which usually assumes the form of a tolerably distinct membrane or pseudo-cyst. This is of course continuous with the tissues in which the parasite is lying, and cannot be removed. The cyst belonging to the parasite itself is usually loosely attached, and can be peeled off without difficulty. Hydatid cysts are found in almost all parts of the body. They are most common in the liver, and occur in other organs in the following order of frequency :—lungs, muscles and subcutaneous tissue, kidneys, pelvis, nervous centres, bones and breast. The parasite not uncommonly perishes. When this occurs, the pseudo-cyst surrounding it may become calcified, and the cyst itself seems to break up in the fluid. In this way all danger is removed, but the tumour remains. In other cases suppuration takes place round the hydatid. The migrating cells penetrate the wall of the parasite, and the whole cavity becomes filled with a

FIG. 357.—Tænia head from Hydatid Cyst. (280 diam.) A single hooklet is shown more highly magnified. (840 diam.)

thin purulent fluid. The cyst-wall often becomes loosened and partially disintegrated. Finally the abscess may possibly burst superficially, and the whole cyst be discharged. I once opened a very large abscess in the adductor region of a young woman's thigh, and gave exit to nearly a pint of pus, containing dozens of hydatid cysts about the size of gooseberries. The *diagnosis* of these cysts when seated in the subcutaneous or muscular tissues cannot be made with certainty, except by withdrawing some of the fluid with the aspirator, and submitting it to microscopic and chemical examination. If it be of low specific gravity and free from albumen, it is almost certain to have come from a true hydatid cyst, and if hooklets are found no doubt remains. The *Treatment* of these cysts when seated in an external part, such as a limb, is complete removal of the parasite by a free incision. In this way I removed a hydatid cyst of the size of a fist from the muscles at the back of the neck of a young man. In internal organs, if enucleation be impossible, aspiration is the best treatment, and is said to cure about half the cases operated on. In spite of antiseptic precautions, aspiration is not uncommonly followed by suppuration. If this occur, or if the aspiration fail to cure, the only efficient treatment is to open the cavity, to attach the walls of the pseudo-cyst to the skin when possible, and to insert a drainage-tube. The parasitic cyst may sometimes be removed from the cavity, but more often this is impossible owing to the softness of its walls, and the small size of the opening that can be made. The operation should be performed with the strictest antiseptic precautions, as the dead parasite and the watery fluid contained in the cyst are highly putrescible, and owing to the size of the cavity septic poisoning is very likely to occur, especially if the drainage and asepsis be imperfect.

II.—TUMOURS COMPOSED OF ONE OF THE MODIFICATIONS OF FULLY DEVELOPED CONNECTIVE TISSUE.

The structures included under the term "connective tissue and its modifications," are fat, fibrous and areolar tissue, cartilage, bone, and mucous tissue. The tumours composed of any of these tissues in a state of perfect development are uniformly benign. Occasionally a cartilaginous tumour assumes a malignant form, but it will then be found that, instead of being covered by a firm fibrous membrane at the margin of the growth, there is a zone of embryonic tissue which is infiltrating the surrounding parts on one side and becoming developed into cartilage on the other—in fact, that the tumour is not a chondroma but a chondrifying sarcoma. It is from this tissue, probably, that the system becomes infected, and not from the fully developed cartilage. In the same way, tumours which to the naked eye seemed to be composed of bone may assume all the characters of malignancy; but on microscopic examination it will be found that they do not grow as normal bone does, either from a fibrous membrane (periosteum) or from cartilage, but are in fact ossifying sarcomata. These will be described amongst the sarcomata. Again, there is no absolute boundary between sarcoma and fibroma. Many tumours composed almost entirely of spindle-cells contain a large proportion of fibrous tissue between the cells. If the fibres very much exceed the cells, the growth would be called a fibroma; if the reverse a sarcoma; and one between the two is often spoken of as a fibro-sarcoma. As a broad rule, it may be said that

the benignancy of the growth will be in proportion to the perfection of the development of the tissue of which it is composed.

a. **Fatty Tumour or Lipoma.**—These tumours occur in any part of the subcutaneous tissue, and at all ages, though they are most commonly met with about the earlier periods of middle life. In the majority of cases they appear to originate without any evident cause ; in other instances they can be distinctly traced to pressure or to some local irritation, as to that of braces or shoulder-straps over the back and shoulders. In one case I have known the disease to be hereditarily transmitted to the members of three generations of a family.

Fatty growths occur under two forms, one diffused, the other circumscribed: it is the latter variety only that is termed the **Adipose or Fatty Tumour**. The diffused form of fatty deposition occurs in masses about the chin or nates and may occasion much disfigurement. This form was described by Brodie under the name of **"fatty outgrowth."**

Fatty tumours may form in all parts of the body as soft, painless, inelastic doughy swellings, usually giving rise on manipulation to a feeling closely resembling fluctuation. They grow very slowly, and are commonly oval or round in form, but frequently lobulated to a most extraordinary degree. They occur most frequently in the subcutaneous fat about the neck and shoulders, and are occasionally met with between muscles, in the neighbourhood of joints and of serous membranes and of mucous canals, sometimes in very unusual situations, where such growths would scarcely be looked for. Thus I once removed a lipoma three inches in length, and as thick as the thumb, from under the annular ligament and the palmar fascia of a young woman. A very curious circumstance connected with these tumours is that they occasionally shift their seat, slowly gliding for some distance from the original spot on which they grew ; thus, Paget relates cases in which fatty tumours shifted their position from the groin to the perinæum or the thigh. I have known one descend from the shoulder to the breast. When growing superficially, they sometimes becomes pedunculated. They may attain a large size, but occasion inconvenience only by their pressure or bulk ; sometimes they appear in great numbers, upwards of 250 tumours of various sizes having been found in the same individual ; and C. v. Lutzau records a case in which they reached the extraordinary number of 2,436. They rarely ulcerate, except when, having attained a great size, they become irritated by the friction of the clothes. In these cases the tumour may be much hardened by an overgrowth of its fibrous tissue. Occasionally patches of calcification are met with. The calcareous matter sometimes forms a layer like an egg-shell, enclosing a space in which the fat is softened and apparently saponified.

Fig. 358.—Fatty Tumour (188 diam.). Some of the cells show crystals of fatty acids.

The typical **lipoma** is simply a mass of fat, usually differing in structure in no way from the ordinary subcutaneous adipose tissue (Fig. 358), but it is not uncommon to find crystalline deposits of the fatty acids in the cells. It is enclosed in a fine thin capsule of areolar tissue, having small vessels ramifying over its surface. This capsule is adherent to the surrounding structures, but loosely connected with the tumour itself; so that, in removing these growths, it is important to open the capsule thoroughly before attempting to enucleate the tumour.

These tumours, which present the least possible deviation from the normal structure of the parts in which they grow, are derived from the connective tissue by an increased development of fat. They present occasionally some minor varieties of structure. Thus the fibrous tissue may be in excess, giving rise to the so-called "fibrous lipoma," or the tumour may be permeated by numerous dilated vessels, as in the "erectile lipoma" or "nævo-lipoma." These conditions are, however, rare. Occasionally mucous tissue may be found intermixed with the adipose, forming the "myxo-lipoma." This will be mentioned again under myxoma.

The **diagnosis** of a fatty tumour is usually easy. It is not adherent to the muscles over which it is lying. This can easily be ascertained by making the patient throw the muscles into contraction, when the mobility of the tumour will be found to remain unaltered. It is more easily confounded with a soft sarcoma or a chronic abscess. The sarcomata usually spring from, or early become adherent to, the deep fasciæ or muscles. On pinching up the skin over a fatty tumour, it will be found to dimple in several places, although it is quite freely movable over the growth. This sign is wanting in a sarcoma. A fatty tumour is distinguished from a cyst or chronic abscess by pressing on its edge, when the solid tumour will be felt to roll away from under the finger; in a collection of fluid, the finger sinks through the edge without the sensation of anything slipping away from beneath it. When the tumour is lobulated, there can be little doubt as to its nature. If any doubt should remain, the mass may be punctured with a grooved needle or a fine trochar.

In the *Treatment* of fatty tumours nothing can be done except extirpation with the knife. The tumour, being but loosely adherent to its capsule, readily turns out if the latter be freely opened, so that the smooth shining surface of the tumour is seen in the bottom of the wound. Great care must be taken that none of the lobules frequently found in these tumours are left behind, as they would certainly serve as starting points for new growths.

b. **Fibroma: Fibrous or Fibroid Tumours, Desmoid Tumours, Areolar and Fibro-cellular Tumours.**—In the healthy body, fibrous tissue is found either dense and firm as in tendons, or loose and filamentous as in areolar tissue, and between these two extremes every variety of density is observed. In healthy areolar tissue two kinds of fibres are almost invariably present: the white fibrous and the yellow elastic tissue. In tumours composed of fibrous tissue, similar variations in density are met with. Thus we have fibrous tumours as dense in structure as ligaments, and others as loose as areolar tissue, but in all it is extremely uncommon to find any yellow elastic fibres. Fibrous tissue enters very largely into the composition of many tumours besides the true fibromata. Thus the stroma of almost all cancers is composed of fibrous tissue, the intercellular substance of a sarcoma may be abundantly fibrous, and in a lipoma the lobules of fat are bound together by areolar tissue.

The term "fibroma" is, however, applied only to those tumours in which fibrous or areolar tissue forms by far the most abundant constituent, and in which all the cells are of the type of connective-tissue corpuscles, and uniformly distributed amongst the fibres. As before stated, no sharp line can be drawn between fibroma and sarcoma, and the term "fibro-sarcoma" is frequently applied to those tumours in the border-land between the two. Fibromata may be divided into two chief classes :—1. Soft fibromata, areolar tumours, and fibro-cellular tumours ; 2. Firm fibromata, desmoid tumours, and fibroid tumours.

1. **Soft Fibromata.**—These may be diffused or circumscribed ; in some cases they are distinctly encapsuled. The diffused variety or *areolar tumours* are little more than a simple hyperplasia of the subcutaneous or submucous areolar tissue. They are represented by pendulous fleshy growths, forming large tumours, commonly called **Wens**, which may occur on any part of the surface. They are smooth, pedunculated, non-elastic, pendulous, and movable, slowly increasing without pain often to a very great size. They are thinly covered with skin, bearing abundant papillæ, and sometimes enlarged sweat-glands and hair-follicles. Large vessels may ramify on the surface, and occasionally the skin is pigmented. They are sometimes congenital. In the disease known as **molluscum fibrosum** these tumours form pedunculated masses or rolls, hanging from the skin of the buttocks, thighs, and other parts of the body, and may attain such a size as seriously to inconvenience the patient by their weight. These masses are composed merely of connective tissue, sometimes dry and tough, sometimes œdematous. They contain large blood-vessels, frequently of such size as to render removal of the growth a most hazardous operation.

Fig. 359.—Pendulous soft Fibroma.

In the *Treatment* of these affections, pressure and iodine applications may be tried in the earlier stages, with the view, if possible, of checking their growth ; at a later period they must, if large, be removed by operation, though this procedure is at times an extremely severe one, owing to their great size and vascularity.

Tumours of the *circumscribed variety*, described by Paget as fibro-cellular, are not of common occurrence ; and when met with they are most frequently found in the scrotum, the labium, the deep muscular interspaces of the thigh or axilla, and on the scalp, in which situation they may form large masses, sometimes weighing many pounds. When seated in the subcutaneous tissue these tumours may become pedunculated, as in Fig. 359, which represents a tumour of this kind which I removed from the side of a woman. I have removed one weighing nearly four pounds from the axilla of a woman, where it lay between the serratus magnus and the ribs. When they occur about the scrotum and labium, these tumours must not be confounded with

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elephantiasis of these parts, from which they may be distinguished by the fact that they are limited and circumscribed masses, and not mere outgrowths. Paget observes that, when occurring about the genital organs, they are found in young women and in old men. They occur only in adults who otherwise are in good health, and grow quickly, forming soft, elastic, rounded, and smooth tumours; they are not attended with any pain. After removal they are found to possess a thin capsule, to be of a yellowish colour, and to contain a large quantity of infiltrated serous fluid, which may be squeezed out abundantly, and coagulates on standing. This fluid may be so abundant as to give rise to distinct fluctuation. Thus, I once removed a soft fibroma from amongst the short muscles of the thumb, which had previously been treated unsuccessfully by puncture, under the impression that it was cystic in nature.

Under the microscope these tumours display a beautifully delicate network of white fibrous tissue, arranged in undulating filaments and fibrous bands, in the midst of which stellate, spindle-shaped, oval or round cells are found. These cells are similar to those normally found in fully developed or growing fibrous tissue. They vary in abundance, but never exceed the fibrous tissue in amount. The cells are rendered more apparent by the addition of acetic acid. These tumours sometimes appear to grow rapidly, when, in reality, the increase in size is due to a rapid increase of the fluid, and not to a new deposit of a solid character in the tumour. As these tumours are perfectly innocent, no hesitation need be felt about their removal.

2. **Firm Fibromata—Fibroid or Desmoid Tumours.**—These tumours are met with in various situations, the most common of which are the bones and periosteum, the subcutaneous connective tissue, and in connection with nerves. In the uterus, "fibroid" tumours are exceedingly common, but in this situation they contain not only fibrous tissue, but also a variable amount of non-striated muscular fibre. Amongst the best known examples of firm fibromata may be enumerated the simple or fibrous epulis, the fibrous tumours of the antrum or lower jaw, the fibrous polypus of the nose, the ordinary or false neuroma, and the painful subcutaneous tubercle. Fibrous tumours are also seen in the neck, especially in the parotid region. In shape these tumours are irregularly oval or rounded; they are smooth, painless, and, except when growing from bone, freely movable; they increase slowly, but may attain an enormous size, equal to that of a cocoa-nut or water-melon. Liston removed one from the neck, which is in the Museum of the College of Surgeons, that weighed twelve pounds; they have, however, been found weighing as much as seventy pounds. They are almost invariably single; they are excessively firm and hard, but yield slightly on pressure, in this differing from bony tumours. When cut into, they present a white glistening fibrous structure, often showing, to the naked eye, bundles of interlacing fibres. Sometimes the fibres show a concentric arrangement (Fig. 360); an appearance which, according to Billroth, is due to the fibrous formation taking place around nerves and vessels. On microscopic examination, pure fibromata are found to be composed of interlacing bundles of white fibrous tissue, scattered amongst which are cells, few in number, and spindle-shaped, stellate, or oval in form (Fig. 361). These are often rendered apparent only by the addition of acetic acid. In most cases the vessels are not abundant, but frequently these tumours can be shown by injection to be very vascular. Sometimes coarse cavernous spaces may be

found. The vessels are intimately adherent to the fibrous structure of the tumour, and consequently, being unable to contract or retract, they pour out enormous quantities of blood if opened by wound or ulceration. This is especially the case in those fibrous tumours which grow from the bones of the head or face, as in the fibrous polypi growing from the body of the sphenoid bone.

Fibromata form most commonly about middle life, and may remain stationary for years. They may, however, suffer various changes. They may undergo disintegration, becoming œdematous, and softening in the centre, or at various points of the circumference; they then break down into a semi-fluid mass, the integuments covering them inflame and slough, and pus, mixed with disorganized portions of the tumour, is poured out, leaving a large and sloughy chasm, from which fungating growths may sprout, readily bleeding on the slightest touch, and giving the sore a malignant appearance; the patient

Figs. 360, 361.—Firm fibromata (188 diam.). Fig. 360, from a small Fibroma of the forehead, shows the circular arrangement of the fibres. Fig. 361, from a naso-pharyngeal polypus, resembles ordinary fibrous tissue.

eventually falling into a cachectic condition, and becoming exhausted by the hæmorrhage and discharge. In other cases these tumours may calcify, or more rarely they undergo true ossification. In rare cases the central parts may undergo a process of softening, so as to form large cysts containing fluid of various shades of colour. Paget relates a case in which a very large cyst of this kind, formed by the hollowing out of a fibroid tumour of the uterus, was tapped by mistake for ovarian dropsy.

Some of the forms of fibroma require further mention here, though they will be mentioned again under the diseases of the organs in which they occur.

Fibromata of Bone.—These may grow in the centre of the bone, as is not unfrequently seen in the lower jaw, or beneath the periosteum. The diagnosis between these latter and the firmer varieties of sarcoma can be made only after removal. Virchow lays great stress upon the fact that periosteal fibromata do not penetrate into the structure of the bone, or show any tendency to infiltrate the surrounding soft parts, while the reverse is the case with the sarcomata.

Fibromata of Nerves.—These are commonly spoken of as neuromata,

although this term would be more properly limited to these tumours in which newly formed nerve-filaments are found. They form rounded tumours, over which the fibres of the nerve are stretched; they are frequently multiple, sometimes extremely numerous, very hard and dense, and almost invariably painless, and not affecting the function of the nerve upon which they grow. They are more movable in a direction transverse to the course of the nerve upon which they are seated than in any other, when the limb is put in such a position as to tighten the nerve; a symptom which is of some importance in their diagnosis.

Painful Subcutaneous Tubercle is a peculiar form of fibroma, found beneath the skin, usually of one of the extremities, but very rarely of the trunk. It is seldom more than half an inch in diameter, and is so small as scarcely to cause a prominence on the surface: yet it gives rise to pain of the most agonizing character, usually called forth by some slight touch or pressure, and then lasting perhaps for an hour or more. These tumours are not neuromata; at any rate, no connexion has as yet been traced between them and nerve-filaments. They are far more frequent in females than in males.

Fibromata of Glands are rare, being almost confined to the mamma.

The *Treatment* of fibromata is in some cases merely palliative; but when they are so situated as to admit of removal, as in the neck, lower jaw, antrum, mamma, or subcutaneous tissue, they should always be extirpated.

Tumours closely resembling fibromata in naked-eye appearance and in consistence have been known to recur after removal with a great tendency to ulceration, sloughing, and hæmorrhage. They may even give rise to secondary deposits in internal organs. These tumours will always be found on microscopic examination to present the signs of one of the forms of sarcoma to be described hereafter. Pure fibromata are invariably benign.

c. **Enchondroma — Chondroma — Cartilaginous Tumours.**— These tumours form an exceedingly interesting group, being of comparatively frequent occurrence, and sometimes attaining a large size.

In structure, a chondroma closely resembles normal hyaline cartilage. The cells vary much in size and shape. In the most typical form they are large ($\frac{1}{500}$ to $\frac{1}{800}$ inch), round, oval, or polygonal in shape, contain a single large nucleus and nucleolus, and are sometimes enclosed in a capsule as in normal cartilage. Occasionally the cells are found to be irregular in shape and branched, the processes of one cell communicating with those of another, as in a myxoma. This form resembles the cartilage normally found only in the cuttle-fish. The matrix may be hyaline, as in normal fœtal or articular cartilage, or may contain a few fibres. It varies much in density, occasionally being so soft as to give the tumour a false feeling of fluctuation. This softness is usually found in the more rapidly growing varieties. The tumour may consist of a single mass of cartilage, or may be composed of innumerable lobules, bound together by vascular bands of fibrous tissue. It is this vascularity that oftens forms the most striking difference between normal cartilage and enchondroma. Its surface may be covered by a distinct fibrous layer, sharply limiting it from the surrounding tissues, or the mass of cartilage may be surrounded by a vascular zone of embryonic tissue, sometimes composed of round, and sometimes of spindle-shaped cells, which may infiltrate and invade the surrounding structures. It is this variety, which is more properly classed as a

chondro-sarcoma, that assumes the characters of malignancy. Enchondromata are liable to various secondary changes. Thus they may undergo true ossification. The ordinary pedunculated or spongy exostosis is usually found to be covered with a thick layer of cartilage, so that it may be spoken of as an ossifying chondroma. Calcification is a far more common change than true ossification (Fig. 362). Not unfrequently mucous softening takes place in the matrix. The cells in this condition float free in the fluid, and undergo degeneration, becoming filled with large globules of fat. This mucous softening may be so extensive as to give the once solid tumour the appearance of a thick-walled cyst. In a case of a very large enchondroma of the ribs under my care a few years ago, I was enabled to make the diagnosis by microscopic examination of a small quantity of such fluid, removed by means of the aspirator. Cartilage may also be found mixed in one tumour with other structures. Thus

Figs. 362, 363.—Enchondroma (188 diam.). Fig. 362.—From a small tumour near, but distinct from, an ossifying enchondroma of the femur; shows the variety in shape of the cells and capsules. At the lower part calcification is taking place involving first the matrix and then the cells. Fig. 363.—From an enchondroma of the finger; matrix faintly fibrillated.

the cartilaginous tumours of the parotid region are seldom, if ever, pure, but contain mingled together the structures of myxoma, adenoma, and enchondroma. Enchondroma and sarcoma are not unfrequently found combined. Encephaloid cancer and enchondroma are said to have been found combined in the testis.

Cartilaginous tumours when composed of pure cartilage are always benign; when mixed with embryonic tissue, as in the chondro-sarcoma, they frequently run a malignant course. The simple chondroma occurs as a hard or slightly elastic tumour, ovoid or round in form, sometimes smooth on the surface but more often lobulated, of small or moderate size, seldom exceeding that of an orange, and growing slowly without pain. The chondro-sarcoma grows rapidly, often attaining an enormous size in a few months, and giving rise to secondary growths in internal organs.

When cartilaginous tumours attain a large size and soften as above described, the skin covering them may become duskily inflamed, and eventually slough, forming fistulous openings, through which a thin, jelly-like matter is discharged.

Locality.—Most frequently chondroma occurs in connection with some bone. It is most commonly seen in the metacarpus and phalanges of the

fingers (Figs. 364, 365). It is rare, in this situation, to find only one bone or phalanx affected; the tumours are almost invariably multiple. They form hard or elastic rounded knobs, seldom larger than a walnut or a pigeon's egg. Large chondromata are most commonly met with in or upon the head of the tibia or the condyles of the femur, forming in these situations rapidly increasing growths of considerable magnitude. Chondromata are found also on the ribs and the bones of the pelvis, in the intermuscular spaces of the neck, thigh, and leg, in connection with the sheaths of tendons, and occasionally in glands; but in this last situation they are seldom, if ever, pure, being mixed with myxoma, adenoma, or sarcoma, and when in the testicle, occasionally with carcinoma. It is a curious fact, that chondromata never arise in connexion with pre-existing cartilage. When connected with the bones, chondroma may spring from the periosteum, gradually enveloping, absorbing, and eventually destroying the osseous structures, though at first not incorporated with them. It has then been distinguished as "perichondroma." This is its usual mode of origin

Fig. 364.—Large Enchondroma of Index Finger.

Fig. 365.—Ordinary Enchondroma of Finger.

when occurring in the femur or tibia; but when seated on the short bones, especially on the metacarpus and phalanges, it commonly springs from the medullary canal, which becomes expanded by gradual absorption of the compact tissue, with a constant growth of new bone beneath the periosteum. Thus the tumour remains long covered by a thin shell of bone. Finally the growth perforates its bony covering at one side, and then advances more rapidly in that direction. These tumours occur in childhood or young adult life. They never assume a malignant form, nor do they ossify. Calcification is common, and mucous softening occasionally, but rarely, takes places in their interior, leading to ulceration of the skin.

The *Treatment* consists either in excision of the tumour, or in amputation of the affected part. Excision may be practised when the tumour is seated in the parotid region, or is otherwise unconnected with bone. When forming part of the osseous structures, it cannot well be got rid of without the removal by amputation of the bone which it implicates. When it occurs in the hand, removal of the affected fingers and metacarpal bones, to an extent proportioned to the amount of the disease, will be required; but it should be remembered that in this situation enchondromata are always perfectly innocent, and consequently the operation should not be performed if the finger be useful to the patient, unless he is willing to sacrifice a useful finger to get rid of an unsightly deformity.

In Fig. 37 may be seen the kind of hand left after operation in the case from which Fig. 364 was taken. If, in these circumstances, excision of the tumour only be attempted, it will be found that the whole mass cannot be removed, and that it rapidly grows again; or that the wound formed by the operation remains fistulous and open.

Removal of a pure chondroma is followed by a permanent cure. The mixed cartilaginous tumours, as chondro-sarcoma or adeno-chrondro-sarcoma, sometimes return after removal, both locally and in internal organs.

d. **Osteoma. Exostosis. Bony Tumour.**—To render the review of the different tumours complete, it will be necessary to mention the osteomata here, though their clinical characters will be more fully treated of in the Chapter on the Diseases of Bones. In the first place, it is necessary to distinguish mere calcification from the formation of true bone. The former is extremely common, the latter somewhat rare. Bone appears in tumours under four chief conditions: 1st, as the result of the ossification of a fibroma; 2ndly, of a sarcoma; 3rdly, of a chondroma; and 4thly, as a special growth covered by a firm layer of periosteum. Only the last two of these forms are properly spoken of as bony tumours or exostoses. They differ from each other in their seat and consistence, as well as in their mode of growth. Those developing from cartilage—spongy exostoses—are situated almost invariably in the immediate neighbourhood of an epiphysis, and rarely, if ever, start into growth after the twenty-fourth year; those developing from a fibrous periosteal covering—ivory exostoses—are of extreme and remarkable density, and are usually seated on flat bones, such as those of the head, face, scapula, and pelvis. Both these growths closely resemble normal bone in structure, the spongy exostosis exactly agreeing with the cancellous tissue of the extremity of a long bone, and the ivory or hard exostosis corresponding to the petrous portion of the temporal, or the compact tissue of a long bone. Both forms are non-malignant.

Fig. 366.—Pedunculated exostoses (natural size).
A. From femur of a boy.
B. From scapula of a child three years old.
a. Hyaline cartilage.
b. Layer of imperfect ossification.
c. Well-formed spongy bone.
d. Periosteum.
The drawing illustrates the different proportions which the various constituents of the tumour may bear to one another.

Spongy Exostoses, sometimes called from their shape pedunculated or cauliflower exostoses, are most common at the upper end of the humerus and the lower end of the femur, and on the ungual phalanx of the great toe (Fig. 364 A). If observed during the stage of growth, they are found to be covered by a perfectly developed hyaline cartilage, which apparently grows from the perichondrium covering it, and quickly undergoes ossification at its deep surface. If the tumour be observed when all growth has ceased, it will be found to be completely bony, being composed of a pedunculated mass of cancellous tissue, thinly covered by a layer of compact bone. The cancellous tissue of the tumour is continuous with that of the bone upon which it grows, the compact tissue of the shaft being absorbed beneath the base of the tumour. Sometimes these tumours are hereditary and multiple. They scarcely ever reach a great size, and probably cease to grow if they become completely ossified.

Ivory Exostoses.—These tumours form flat rounded elevations, usually seated on the bones of the skull or face. They are covered by a fibrous membrane and are of extreme hardness. Occasionally they are multiple and grow to a considerable size, and when seated on the facial bones distort the features horribly, and at last after years of suffering possibly cause death by pressure on the brain.

e. **Myxoma. Mucous Tumour.**—These tumours are classed by some writers under sarcomata, as the tissue of which they are composed closely resembles the rudimentary fat of the fœtus. In the adult, the vitreous body of the eye is the only part in which mucous tissue is normally found. Many tumours formerly described as colloid cancer belong to this class. Myxomata usually form round, oval, or lobulated masses, distinctly surrounded by a loose capsule of connective tissue. They are tense, elastic, and gelatinous, frequently giving rise to a feeling of fluctuation so distinct as to lead to their being mistaken for cysts. They are usually of slow growth. On section they

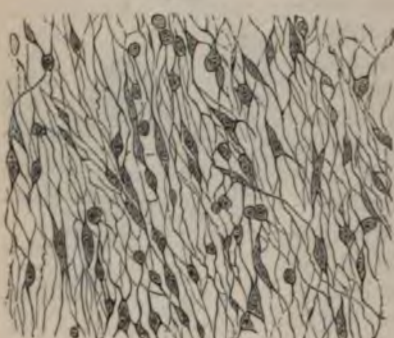


Fig. 367.—Myxoma, from a large tumour in the skin of the back (188 diam.). It will be noticed that even the round cells are connected with those which are more branched.

Fig. 368.—Mucous Polypus of Nose (188 diam.). The round cells vary in size and are distinct from the branched ones. The branched cells are very irregular, and the matrix somewhat fibrous.

are found to be of a delicate pink colour, sometimes stained by hæmorrhages, or they may exhibit a uniform yellowish tint. The most marked peculiarity they present on section is in the fluid which flows from the cut surface. This is abundant, glairy, and tenacious, having the appearance of thick gum-water. On chemical examination it is found to contain mucin ; microscopic examination shows (Fig. 367) in the purest forms of myxoma a beautiful network composed of large stellate or branched cells, the processes of which freely communicate with one another. These cells are imbedded in an almost homogeneous intercellular substance, in which vessels can be clearly seen to ramify. It is seldom, however, that this structure is found so pure as this. In addition to the stellate cells, numerous small round cells (Fig. 368) are usually present, and the intercellular substance is in most cases traversed by delicate bundles of fibrous tissue, sometimes containing yellow elastic fibres. The stellate cells may be smaller in some cases than in others. The peculiar feature of the growth is the mucous intercellular substance, and without this being present no tumour should be called a myxoma. Frequently, tissue agreeing in all respects with that of a pure myxoma is found mixed with that of sarcoma,

enchondroma, or adenoma. The tumours are spoken of as myxo-sarcomata, myxo-chondromata, &c. Myxo-chondroma, frequently containing portions of adenoma, forms the ordinary parotid tumour. Occasionally a development of true fat cells may take place in the central parts of a myxoma, thus indicating, as Virchow thinks, the relation of these tumours to embryonic fat. A few years ago I saw a case of an enormous abdominal tumour which proved after death to be a pure myxoma, weighing at least thirty pounds, the central parts of which contained an abundance of true adipose tissue. Such tumours as these have been spoken of as myxo-lipomata. I have since seen a similar abdominal tumour in a young man. After death it was found to be composed almost entirely of pure myxoma tissue. A few small nodules of spindle-celled tissue were found in it, but no fat. Myxomata may occur in any part of the body. When superficial they often assume a polypoid form, as in the ordinary mucous polypus of the nose. Myxomata are not unfrequent in the subcutaneous cellular tissue; in nerves they form one variety of false neuroma, and they are occasionally met with in glands. They are usually non-malignant, but occasionally they occur locally after removal. If left untreated, they may cause death by ulceration of the skin taking place over them, leading to the sloughing of the tumour with profuse hæmorrhage and foul discharge. Occasionally they may prove fatal from pressure on important organs, as in the case of the abdominal tumour above mentioned. The *Treatment* consists in the removal of the growth whenever possible.

III. TUMOURS WHICH RESEMBLE IN STRUCTURE, MORE OR LESS PERFECTLY, ONE OF THE MORE COMPLEX TISSUES OF THE BODY.

A. **Myoma. Muscular Tumour.**—These tumours are of two classes: those containing striated muscular fibre, or *rhabdomyoma*, and those containing non-striated muscular fibre, or *leiomyoma*. Striated muscular fibre has, at present, been found only in a few congenital tumours, chiefly in large growths in or near the kidney, in which it is mixed with spindle-celled sarcoma and cysts lined with epithelium. Non-striated muscular fibre is found in abundance in the so-called fibroid tumours of the uterus and of the prostate, but it is always associated with large quantities of fibrous tissue, so that the tumour is more properly spoken of as a fibro-myoma. The older tumours are found to be composed almost entirely of fibrous tissue, the muscular fibre cells having undergone atrophy. Pure myomata have, in very rare cases, been found in connection with the muscular coat of the alimentary canal and urinary passages. Fagge has recorded an interesting case of myoma of the œsophagus, which was accidentally discovered after death, at Guy's Hospital. It gave rise to no symptoms during life, although the tumour was as large as a good-sized egg. Myomata are always non-malignant.

Fibro-Myoma of the Uterus.—These tumours are composed of long spindle-shaped muscular fibre cells and fibrous tissue in varying proportions. According to the position of the tumour in the wall of the uterus they are described as subserous, interstitial or submucous. In the tumours of old women the muscle cells often atrophy, and the growth then presents the appearance of a pure fibroma. They are liable to softening and ulceration, and are often accompanied by much hæmorrhage when they assume the

polypoid form. They frequently calcify and occasionally, as above stated, soften, forming enormous cysts.

B. **Neuroma. True Neuroma. Nervous Tumour.**—The term "neuroma" is applied clinically to any tumour growing on a nerve, whether it be a fibroma, myxoma, sarcoma, or true neuroma. The term should strictly be limited to those rare tumours in which there is an actual new growth of nervous tissue. Neuromata composed of grey matter (non-medullated fibres and ganglionic tissue) have been described, but they are so infinitely rare that they need no further mention here. The vast majority of true neuromata are composed of bundles of medullated or white nerve fibres, interlacing with each other, or sometimes rolled up into masses, and separated by connective tissue, more or less rich in small cells. True neuromata occur only in connection with nerves. As examples may be mentioned the bulb which forms on the central end of a divided nerve or on the nerve in a stump; the latter is called an "amputation neuroma." True neuromata occur also without previous injury of the nerve. They are then frequently multiple. They cannot be diagnosed from other firm tumours of nerves. They are sometimes painful and tender, and sometimes not. The most characteristic sign of any tumour seated on a nerve is, that when the nerve upon which it is seated is put on the stretch by the position of the part, the tumour is almost immovable in a direction parallel to the course of the nerve, while it is more or less freely movable in the transverse direction. True neuromata are always non-malignant, and should not be interfered with unless they give rise to serious inconvenience from pain.

A peculiar and very rare form of tumour has been described under the name of *plexiform neuroma*. It consists of a group of small nerves the terminal twigs of which are thickened by the growth of new fibrous tissue, convoluted and twisted upon one another and bound together by areolar tissue. If unravelled the separate cords present a varicose nodular appearance. According to Bruns, the tumour is partly composed of new nerve fibres. It is most commonly met with in the face and neck, and may be congenital.

C. **Angioma. Nævus. Vascular Tumour.** — Under the name of angiomata are included only such tumours as are composed of vascular tissue of new growth, and not such swellings as arise from the dilatation of pre-existing vessels. The so-called cirsoid aneurism, or aneurism by anastomosis, being supposed to be due chiefly to a dilatation of pre-existing arteries, although doubtless accompanied by some new formation of vessels, is not usually included amongst angiomata, nor are the swellings formed by convoluted masses of varicose veins. True angiomata are usually divided into two classes:—*the plexiform angioma* or *telangiectasis*, and *the cavernous angioma*. The *plexiform angioma* is composed of a mass of tortuous and dilated capillaries bound together by connective tissue (Fig. 369). The blood-vessels comprising it are normal in structure. This forms the ordinary superficial nævus, "mother's mark," or "port-wine stain." It is, probably, always congenital. The *cavernous angioma*, or erectile tumour, resembles in structure the corpus cavernosum penis, being made up of spaces, communicating freely with each other. The walls of the spaces are composed of fibrous tissue, and are lined with an endothelium resembling that of a vein. These tumours are sometimes distinctly circumscribed, and enclosed in a loose capsule of connective tissue; in other cases they are diffuse. They are sometimes congenital,

but often arise in young adult life. They are most common in the subcutaneous tissue, but have also been met with in muscles, and in the liver, spleen, and other internal organs. The mode of origin of these tumours is doubtful. They appear sometimes to develop as a result of an injury.

The symptoms and treatment of vascular tumour will be fully described in a subsequent chapter.

D. **Lymphangioma. Lymphatic Nævus. Tumour composed of Lymphatic Vessels.**—These excessively rare tumours are composed of a network of fine lymphatic vessels or of dilated lymphatic spaces communicating with each other, like those of the cavernous angioma, the cavities containing lymph instead of blood. Congenital forms of lymphangioma are met with in the conditions of hypertrophy of the tongue (macro-glossia) and

Fig. 369.—Nævus (454 diam.). The endothelium apparently almost obstructs the lumen of the vessels as the result of their contraction.

Fig. 370.—Nævus (188 diam.) infiltrating fat. The shaded bands represent vessels out of focus, the ends of some of them being shown in transverse section.

of the lips (macro-cheilia); also in the neck and occasionally elsewhere as a multilocular cystic tumour—the *cystic hygroma*. This tumour is situated in the subcutaneous tissue, and also forms one variety of congenital sacral tumours. It is composed of a number of thin-walled cysts, sometimes completely closed and sometimes communicating with each other; the separate cysts are held together by areolar tissue, in some cases containing fat. The contents are clear and serous. The walls of the cysts are lined in some cases with an endothelium like that of the lymphatics. These tumours often attain a great size in the neck and sacral region, but in other situations they are seldom very large. If their size permits, they can be removed; other modes of treatment have not proved successful.

E. **Lymphadenoma. Tumour composed of Lymphatic Tissue. Lymphoma.**—Lymphadenomata are composed of tissue exactly resembling that of the follicles of the lymphatic glands, lymphoid or lymphatic tissue, the so-called "adenoid tissue" of His; but to avoid confusion, the term "adenoid" should never be used in connection with this structure, but reserved for tissues resembling those of the secreting glands. Lymphoid tissue (Figs. 371, 372) is characterized by a delicate reticulate stroma, in the meshes of which are

packed cells, in every way resembling the white corpuscles of the blood. The stroma is composed of fibrous tissue containing a few oval nuclei scattered through it, especially where the bands cross each other. The stroma may, in some cases, be increased in amount and thicker than that normally found in lymphatic glands. The vessels are abundant and in close connection with the stroma. The tumours are white or grey in colour, sometimes stained by hæmorrhages. They vary considerably in consistence; sometimes they are soft and brain-like, and sometimes hard and tough. This difference depends upon the proportion borne by the cells to the stroma. The softer forms yield an abundant milky fluid on scraping, resembling the juice of a cancer. The lymphoid character of the cells in the fluid, however, at once shows the true nature of the growth. The development of these tumours forms the essential feature of the general affection known as "Hodgkin's disease." In this affection there is an enlargement of the lymphatic glands, accompanied in some cases by disseminated lymphoid tumours in the liver, spleen, kidneys, and

Fig. 371.—Lymphadenoma (454 diam.). Some of the cells have been removed to show the arrangement of the stroma.

Fig. 372.—Lymphadenoma (188 diam.). Shows general arrangement.

other organs, and occasionally in the medullary tissue of bones. To this general form of the disease, Gowers applies the name of *lymphadenosis*. The chief general symptom is marked and progressive anæmia. The red corpuscles of the blood are diminished in number, and the white may or may not be increased. The increase in the white corpuscles is met with chiefly in those cases in which the tumours are soft and disseminated throughout the viscera, and more especially when the spleen is enlarged. The disease may occur at any age, but is most common in young adults. For the further symptoms, the reader must refer to works on medicine. Lymphadenoma comes under the care of the Surgeon only as it occurs in the lymphatic glands. The glands of the neck and axilla are most frequently affected. They form painless swellings, usually firm in consistence, and of slow growth, and are at first indistinguishable from simple hypertrophy or chronic inflammatory enlargement. The glands remain distinct till they have acquired a considerable size; but later on they may fuse together, forming a large lobulated mass. While they remain distinct, they form no adhesions to surrounding parts, and can easily be removed; but when the growth extends beyond the capsules of the glands, it may infiltrate surrounding structures. They show no tendency to caseation, and never soften or suppurate. The skin covering

them is not adherent and retains its natural colour. The affection may remain for a long time, or even permanently, limited to one set of glands. In these cases, as a rule, the stroma is in great excess, and the tumours are hard and fibroid. After a time they may cease to grow. When large numbers of glands are affected and disseminated growths are present in the viscera, the growths are usually, but not always, softer, and the case almost inevitably terminates fatally after two or three years. Death may take place from the general disease, or from the effects of local pressure, especially when the growth extends beneath the sternum, or presses on the trachea or recurrent laryngeal nerve.

Lymphadenoma frequently comes under the observation of the Surgeon affecting a single gland or group of glands unaccompanied by any constitutional disturbance. In these cases the disease seems to be a mere hypertrophy of the affected glands ; and perhaps, strictly speaking, should hardly be classed with tumours. The diagnosis of lymphadenoma in the early stages is practically impossible. At a later period, the great enlargement of the glands, and the constitutional symptoms, indicate the nature of the case. The absence of a local cause of irritation, and the want of any tendency to caseation or suppuration, serve as a rule to distinguish it from chronic inflammation of the glands. The question of removing the enlarged glands often comes before the Surgeon. If the affection is local, and the general health fairly good, the operation may safely be undertaken. If there is very marked anæmia, or if there be a high temperature, and especially if the tumours are very numerous, the spleen enlarged, and the white corpuscles distinctly increased in number, any operative interference should be avoided unless it seems possible to relieve the patient from imminent death from pressure on the trachea.

F. **Papilloma. Tumour resembling the Papillæ of Skin or Mucous Membrane.**—A papilla is a more or less pointed projection composed of connective tissue, surrounding a capillary loop and covered by epithelium, which may consist of many layers, as in the skin, or of only one, as in the intestine. Lymphatic spaces and capillaries are present in the areolar tissue. The tumours which pass under the name of papillomata are usually mere hypertrophies of the normal papillæ of the part on which they grow, and are covered by the variety of epithelium natural to the part. The papillæ of which they are composed differ from those normal to the part in size, shape, and vascularity. Thus, instead of merely microscopic papillæ, such as are normal to the skin, we may have growths sometimes reaching the size and presenting the appearance of the head of a good-sized cauliflower. Instead of simple papillæ, we may have branched growths subdividing again and again, and connected with the parent tissue only by a narrow stalk. The vessels of these growths are always abundant, and frequently dilated to a considerable size. The connective tissue forming the basis of the papillæ is more or less crowded with small round cells, according to the rapidity of the growth. Sometimes the deeper layers of the epithelium are darkly pigmented. Malignant tumours of various kinds when seated on a free surface may assume a papillary form, but these must not be confounded with papillomata. On the other hand, a papilloma may by invisible degrees merge into a squamous or columnar carcinoma, the distinction between them sometimes being difficult, even with the help of the microscope. So long, however, as the tumour maintains a simple papillary form, the epithelium being

altogether superficial, and showing no tendency to burrow between the papillæ into deeper parts, the tumour is non-malignant. In other cases, such as the common warts or gonorrhœal warts, the growth is always simple. Papillomata vary in hardness and softness, according to the parts on which they grow, and the amount and nature of epithelium with which they are covered. Thus the common corn or wart, being thickly covered with horny epithelium, is hard, while the papillomata of the rectum, being thinly covered with columnar epithelium, are soft.

The chief forms of papilloma are :—corns, simple warts, condylomata and mucous tubercles, and some forms of polypi and villous tumours.

Corns consist of an undue development of cuticle, with slightly increased vascularity of the subjacent cutis; subsequently the papillæ themselves become enlarged, especially when the irritation has been prolonged or con-

Fig. 373.—Papilloma of Soft Palate. (40 diam.)

a. Superficial epithelium.
b. Younger epithelium: in the deeper parts the cells are more deeply stained and radiate from the centre.
c. Connective tissue forming the papillæ, into the ramifications of which it is prolonged.
d. Vessels cut obliquely.

siderable. A soft corn is merely one which from its situation is kept constantly moist, so that the newly formed scaly epithelium, instead of forming a dense crust, peels off, leaving the vascular and sensitive papillæ but thinly covered.

Warts are the result of a primary hypertrophy of the papillæ, accompanied by the formation of new vessels, and a great increase in the development of the epidermis, which forms laminated strata, and sometimes produces, in the hollows between the papillæ, masses with a concentric arrangement of the cells, closely resembling the nest-like structures seen in squamous carcinoma. The true warts are most commonly found on the skin, and are then often very hard and horny; sometimes they may develop a long horn-like growth. Softer varieties are, however, found on the muco-cutaneous surfaces, especially of the prepuce and vulva, and are usually of specific origin. They may also occur on the mucous membrane of the mouth or soft palate (Fig. 373), and they are not uncommon in the larynx.

Warty growths on the vulva, the result of gonorrhœal irritation, may reach the size of a fœtal head. Simple cutaneous warts are often pigmented, being of

a bluish-black colour. In these the papillæ may not be evident to the naked eye, the spaces between being filled up with epithelium, but the papillary structure is readily demonstrated by the microscope.

In **Condylomata and Mucous Tubercles** the enlarged papillæ are soft, and contain a great abundance of small round cells, giving evidence of their rapid growth. They occur about the anus and in the perinæum and folds of the nates, as well as occasionally in the larynx and fauces. They are always dependent on a syphilitic taint. When situated on the mucous membranes, they are often pointed, somewhat pendulous, nodulated on the surface, very vascular, and bleed readily when touched; but when they occur on a muco-cutaneous surface, they are flattened, expanded, soft, and white, constituting the true condylomata or mucous tubercles.

Some forms of **polypi** are properly classed amongst papillomata. Thus the simple polypus of the rectum may be a soft papilloma bearing columnar epithelium. In some rare cases, the epithelium has been found to be scaly. The papillæ may branch again and again, the pedicle being comparatively small. It is difficult, however, to draw any accurate line between such papillomata and the columnar carcinoma to be described hereafter.

Villous tumours of the bladder, formerly described as "villous cancer," are also papillomata. These tumours are composed of long delicate processes floating freely in the cavity of the bladder. They each consist of a dilated capillary loop, surrounded by an almost homogeneous connective tissue, containing a few scattered round or oval cells, and covered with an epithelium of an irregular shape, often resembling spindle cells in form, and similar to that naturally lining the bladder. This epithelium is very difficult to find, as it soon separates by maceration in the urine after death. The base from which the villi grow is composed merely of fibroid tissue tunnelled in all directions by dilated vessels. These tumours, if left unrelieved, invariably terminate fatally from the abundant hæmorrhage to which they give rise, and the interference with the escape of urine from the bladder; but they never give rise to secondary growths nor invade surrounding structures, and are consequently non-malignant. They will be more fully described under diseases of the bladder.

The general principles of *Treatment* of these affections consist in their removal by excision, ligature, or caustics, according to their size, situation, and attachments. Excision is usually preferable when they are of large size. If they are seated on a mucous surface, and are pedunculated, the ligature is the safest means of removal. In many cases Paquelin's cautery will be found very useful in removing large papillary growths. Small warty growths on the skin or on a muco-cutaneous surface can usually be cured without difficulty by the application of salicylic collodion. (Salicylic acid, gr. 100, flexible collodion [$\frac{3}{4}$ strength], one ounce.) Extract of Indian hemp is sometimes added to this to prevent pain, and the preparation is then known by the name of "Solvine." (Salicylic acid, 60 grains, extract of Indian hemp, 8 grains, and flexible collodion [$\frac{3}{4}$ strength], one ounce.) If the cuticle be very thick the wart may be cured by the application of a saturated solution of potassa fusa in water.

The term **"polypus"** may conveniently be defined here. It is purely clinical, and has no pathological meaning. It merely means a tumour growing from the mucous surface lining a cavity, having a distinct peduncle and a

rounded, oval, or papillary form. Thus the ordinary polypus of the nose is usually a myxoma, and the malignant polypus a sarcoma. Polypus of the uterus is a fibro-myoma, and polypus of the rectum often a papilloma, and sometimes a form of cancer. Simple polypi are usually covered by a prolonga-

Fig. 374.—Adenoma (adeno-fibroma) of Mamma, of slow growth (188 diam.). Stroma bears a large proportion to the spaces; it consists of well-formed fibrous tissue. Tubes contain more than one layer of epithelium.

tion of the mucous membrane from which they grow. Thus the mucous polypus of the nose is covered by a membrane bearing ciliated epithelium.

G. **Adenoma. Glandular Tumours.**—These tumours resemble secreting

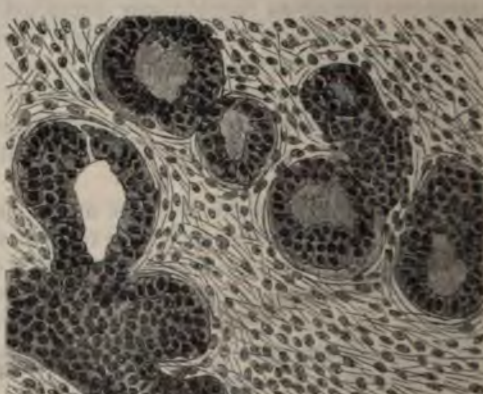


Fig. 375.—Adenoma (adeno-sarcoma) of Mamma, rapid growth (188 diam.). This is sometimes spoken of as adeno-sarcoma; the epithelium in the acini is arranged in several layers, the stroma contains many oval cells and some fibres.

glands in structure. Secreting glands are racemose or tubular, and consequently adenomata are divided into two corresponding classes.

The **Tubular Adenomata** are composed of masses of tubules resembling those of the structure in which they originate, some closed and some open on the surface. In the rectum or intestine the tubes resemble the crypts of Lieberkühn. These tumours are usually papillary. They often form polypoid

growths. When simple and with well marked papillæ, they might perhaps be more properly spoken of as papillomata, and they were consequently mentioned under that class. When showing the well marked malignancy so common to these growths, they are classed with carcinomata, either under the name of columnar epithelioma, columnar carcinoma, or adenoid cancer. They will therefore, be more fully described hereafter.

In the skin a tubular adenoma is occasionally met with arising from the sweat-glands. It forms a flattened elevation, arising about one-tenth of an inch above the level of the surrounding parts, and somewhat coarse on the surface. A section shows it to be composed of closely packed tubular glands exactly resembling those of the normal sweat-glands. These growths are very rare. They may ulcerate in the centre after reaching a certain size and by invading the surrounding parts show a local malignancy, but they never give rise to secondary growths.

The **Racemose or Acinous Adenomata** resemble in structure more or less perfectly a racemose gland, and are always found in connection with such organs (Figs. 374, 375). They are composed of rounded or irregular spaces lined with a peculiar small epithelium, somewhat square or rounded in form, and frequently many layers deep. The spaces communicate with each other, either directly or by means of duct-like channels. The acini, which are more or less widely separated, are bound together by fibrous tissue, bearing vessels, and containing cells varying in shape and number. In the most typical forms the cells are merely such as are seen in ordinary connective tissue; but if the tumour be growing rapidly, large numbers of small round or oval cells are found (Fig. 375). Sometimes the tissue between the acini may be composed entirely of spindle cells, in fact, may have the structure of a spindle-celled sarcoma; the tumour is then often spoken of as an adeno-sarcoma. Sometimes tissue resembling that of a myxoma may be found. Very frequently the acini become dilated into cysts, varying in size from a pin's head to a walnut, or larger; this forms the so-called cysto-sarcoma of the mamma. Not unfrequently in such cases cauliflower-like intra-cystic growths, similar in structure to the rest of the tumour, may be found projecting into the cysts. These tumours are most frequent in the mamma, but they are sometimes seen in connection with the parotid, and have been recorded as growing from the racemose glands of the soft palate, from the lachrymal gland, and from the sebaceous glands of the skin. In the parotid they are often mixed with myxoma and enchondroma. They are rounded or oval in shape, perfectly circumscribed, and surrounded by a fibrous capsule. They are hard and elastic, occasionally presenting points of fluctuation when containing large cysts. They are always non-malignant, and there is no reason to believe that they ever assume a carcinomatous character. Their clinical features and treatment will be fully discussed in the chapters on the diseases of the organs in which they occur.

IV. TUMOURS COMPOSED OF TISSUE WHICH IS EITHER PURELY EMBRYONIC, OR IS UNDERGOING ONE OF THE PRIMARY MODIFICATIONS SEEN IN THE DEVELOPMENT OF ADULT CONNECTIVE TISSUE:— SARCOMATA.

The large group of tumours classed under the name of **Sarcomata** includes many which were, till comparatively recently, known by a variety of other

names, and grouped in other divisions: and the term "sarcoma," which has now received a definite meaning, was formerly applied to almost any soft fleshy growth. Almost all soft sarcomata of bones, the glioma or glio-sarcoma of the eye, sarcomata of secreting and lymphatic glands, were formerly called soft cancer; the melanotic sarcoma,—melanosis or melanotic cancer; the ossifying sarcoma,—osteoid cancer; and the chondrifying sarcoma,—malignant enchondroma. Many firm sarcomata have been described as scirrhus, and soft sarcomata broken down by hæmorrhage as blood-cysts. Lastly, the tumours known as fibro-plastic, fibro-nuclear, recurrent fibroid, malignant fibroid, and myeloid, have all been brought into the great class of sarcomata. These tumours may grow in any part of the body. They may present every variety of consistence, colour, and shape; they may be circumscribed or diffuse: they may be as innocent as a fatty tumour, or as malignant as the worst form of cancer. The anatomical type of sarcoma is found in embryonic tissue, a description of which has been given in a former page (p. 1002). Its pathological analogue is seen in the products of inflammation, but between these and sarcoma are many differences. The products of inflammation, supposing they live, show a tendency towards development into some more perfect tissue; but in a sarcoma the older parts of the growth show no higher development than the most recent, the same type of structure being as a rule maintained throughout. The ossifying and chondrifying sarcomata and some fibro-sarcomata are, however, exceptions to the rule. Inflammatory new growths tend speedily to limit themselves, sarcomata to grow indefinitely. In sarcoma, the individual elements are often larger than those seen in inflammation.

The cells of sarcomata vary greatly in shape and size, and it is chiefly according to these variations that this group is subdivided. The cells consist simply of a mass of protoplasm surrounding one or more nuclei, and not enclosed in a cell-wall. They may be small and round, exactly resembling the white corpuscles of the blood, or large and round, looking almost like epithelium cells; they may be oval, spindle-shaped or fusiform, stellate or tailed; giant cells crammed with nuclei may be found, and occasionally the cells are pigmented. The intercellular substance may be scanty or abundant, homogeneous or fibrous, but whenever it is recognizable it is seen to penetrate between the individual cells in the greater part, if not in the whole of the tumour, and thus a broad distinction is established between these growths and carcinomata, in which the stroma forms alveolar spaces, the cells lying free within them. Occasionally the growth may ossify or chondrify. The blood-vessels of sarcomata are usually abundant and thin-walled, resembling those of newly formed granulations; whilst in some tumours the blood-vessels are little more than clefts bounded by the actual cells of the tumour. This makes these tumours prone to bleed, both into their own substance and externally, and may perhaps account for the readiness with which many sarcomata propagate themselves in the direction of the circulation. In some forms the vascularity is such that the whole mass pulsates expansively, and on auscultation a loud bruit may be heard, and thus the tumour may easily be mistaken for an aneurism. No lymphatics have been demonstated in sarcomata. These growths are usually prone to early degeneration. They most commonly undergo fatty degeneration in their central parts, but occasionally they may calcify; mucous softening also may take place. When they reach the surface

they may slough and ulcerate, forming foul cavities, sometimes of great size; but more commonly, when relieved from the pressure of the skin, they form large fungating protrusions, often bleeding profusely, the so-called "*fungus hæmatodes*." Cysts are of frequent occurrence in some forms of these tumours. On scraping after a section has been made, sarcomata do not yield a milky juice when fresh, but after about twenty-four hours it can often be obtained. Some sarcomata are distinctly circumscribed and enclosed in a fibrous capsule; others infiltrate surrounding parts like the carcinomata. Sarcomata are most frequent in youth and middle life, but may occur at any age. As a rule, it may be said that sarcomata infect the system through the medium of the blood-vessels, while carcinoma is disseminated chiefly by the lymphatic system. This rule has many exceptions, yet nothing is more common than to see secondary growths of sarcoma in the lungs, liver, and other organs, without the lymphatic glands having ever been affected. The reverse is the rule in carcinoma. It may also be broadly stated that, the more closely a sarcoma approaches to fully developed connective tissue in its structure, the less likely it is to prove malignant; but this rule is not free from exceptions. Sarcomata vary greatly in their rate of growth, some proving fatal in less than a year, others lasting many years without attaining any considerable size. Sarcoma tissue sometimes occurs mixed with other kinds of growth.

VARIETIES OF SARCOMA.—**Small-Round-celled Sarcoma. Granulation Sarcoma. Encephaloid Sarcoma.**—These tumours were formerly included among soft or encephaloid cancers. They resemble in structure the superficial layers of granulations, being composed of small round cells about the size of a white blood-corpuscle, or a little larger, each containing a round or oval nucleus, and imbedded in a homogeneous intercellular substance (Fig. 376). Sometimes the intercellular substance is scarcely perceptible, sometimes it is more abundant, as shown in the accompanying figure. It may be more or less distinctly fibrillated. These tumours are soft, sometimes even pulpy, and grey or whitish in colour. They usually infiltrate surrounding parts. They are excessively vascular, and often present scattered patches of hæmorrhage or cysts resulting from extravasation of blood. They may pulsate forcibly, and have more than once been mistaken for aneurisms. They yield no milky juice when quite fresh, but when decomposition sets in, it can easily be obtained by pressure or scraping. Their chief seats are the skin, bones, subcutaneous areolar tissue, muscles, and occasionally glands. The diagnosis cannot be accurately made till after removal. They show a malignancy equal to that of the worst carcinomata. Their growth is rapid, and they early give rise to secondary deposits, especially in the lungs, and the lymphatic glands are frequently affected.

One form of small-round-celled sarcoma has been described by Virchow under the name of **Glioma,** from its resemblance in structure to the neuroglia or connective tissue of the brain and spinal cord, from which it always springs It is composed of an excessively delicate areolar stroma, having round cells imbedded in its meshes. Ziegler states that the apparent areolar stroma is in fact composed of numerous branching processes going off in all directions from the cells. These tumours vary much in consistence, being sometimes soft and sometimes quite firm. They are never circumscribed, always invading the surrounding parts. They occur in connection with the nerves or nervous centres. The tumour formerly known as soft cancer of the eyeball is in fact

a glioma arising from the retina. It is most common in young children, and frequently runs a malignant course, projecting beyond the eyeball, infiltrating surrounding parts, and giving rise to secondary growths.

Another variety of small-round-celled sarcoma is the **Lympho-sarcoma.** It is distinguished by the character of the stroma, which consists of a fine reticulum. After pencilling or shaking a thin section in order to remove some of the round cells, it will be found that the reticulum is formed by the branching processes of small nucleated cells. The structure of the tumour thus closely resembles that of a lymphadenoma. Lympho-sarcomata occur chiefly in mucous membranes and lymphatic glands, but occasionally affect the tonsil and testis. They tend to cause secondary disease of the lymphatic glands at an early stage of their growth.

Spindle-celled Sarcoma. Fasciculated Sarcoma. Recurrent Fibroid Tumour. Fibro-plastic Tumour.—These tumours are composed of spindle-shaped, fusiform, or oat-shaped cells, either lying closely in contact with each

Fig. 376.—Round-celled Sarcoma, from a large tumour in the muscles round the upper end of the femur (188 diam.). The cells vary in size and have a very clear nucleus and nucleolus; the matrix which has shrunk away from the cells is faintly granular.

Fig. 377.—Spindle-celled Sarcoma, from subcutaneous tissue of groin (188 diam.). Cells of medium size; no intercellular fibres.

other or separated by a homogeneous or fibrous intercellular substance (Fig. 377). The cells vary greatly in size in different tumours, but are usually tolerably equal in the same growth. They may be little more than $\frac{1}{1000}$th inch in length, or they may reach entirely across the field of the microscope. This has given rise to the distinction between large and small spindle-celled sarcomata. The intercellular substance is usually more abundant and more fully developed into fibrous tissue in the small than in the large-celled growths; and it is the former, therefore, that gradually merge into fibromata, so that it is often difficult to determine under which heading to class them, and some writers have given them the name fibro-sarcoma. All spindle-cells, large or small, contain an oval nucleus with one or more nucleoli. The cells are usually arranged in bands crossing each other in various directions, often giving the growth a fasciculated or fibrous appearance, and if a band happens to be cut transversely it presents the appearance of a group of small round cells. The vessels, as in other sarcomata, are abundant and thin-walled.

The *small-spindle-celled sarcomata* are usually firm in consistence, and of a pinkish or whitish colour, the central parts being yellow from fatty degeneration. Occasionally they contain cysts filled with straw-coloured fluid, and they may closely resemble in aspect the common fibroid tumour. They grow

by preference in fibrous structures, as fasciæ, skin, or tendons; they may occur in intermuscular spaces, or occasionally in the sheaths of nerves. Thus I have amputated a leg for a large tumour of this kind seated on the posterior tibial nerve. Though these tumours are usually distinctly circumscribed and sometimes encapsuled, and run a perfectly innocent course, in many cases they show an extraordinary tendency to local recurrence after removal; but it is rare for them to give rise to secondary deposits in internal organs. Paget described these growths under the name of *recurrent fibroid tumours*, and related several instances of them. One was a tumour of the upper part of the leg, which between 1846 and the end of 1848 had been removed five times, and reappeared for the sixth time after the last operation, when, as it had become large and ulcerated, amputation was deemed advisable; this procedure, however, was followed by death. The examination of the third tumour presented "very narrow, elongated, caudate, and oat-shaped nucleated cells, many of which had long and subdivided terminal processes;" in the tumour last removed, the cells were generally filled with minute shining molecules, as if fatty degeneration had taken place. In another case, a tumour of the shoulder had been removed, and returned four times between May, 1848, and December, 1849, reappearing in the following year for the fifth time; it, however, after a time became stationary, and many years afterwards the patient, but for the presence of the tumour, might be considered a strong and healthy man. Paget also relates a case in which, between 1839 and 1851, Syme removed a tumour of this kind five times from the upper part of the chest; a sixth recurrence was followed by death. He refers also to a case by Gluge, in which a similar tumour was five times removed from the scapula, its sixth reappearance being followed by death. The most interesting of all is a case by Maclagan, in which four removals were performed in the course of thirty-six years, twenty-three years intervening between the second and third removals, and eleven between the third and fourth. The recurrent tumours appear to be more malignant in the later than in the earlier recurrences, becoming more painful, rapidly degenerating, and giving rise to an ulcerating fungus, which eventually proves fatal by exhaustion and hæmorrhage. The cells will then be found to have become larger, and the intercellular substance softer and devoid of fibrillation; and, in fact, they merge into the large-celled form of spindle-celled sarcoma. This is clearly shown by a case which occurred under my care at University College Hospital. A tumour as large as a full-sized turnip was removed from the shoulder of a middle-aged man, and was found to be slightly connected with the spine of the scapula. On examination it presented all the characters of a spindle-celled sarcoma, consisting almost entirely of densely packed fusiform cells, with oval or oat-shaped nuclei. A small mass reappeared before the wound had completely healed, and on examination presented a much larger proportion of oval cells and spindle cells, now having double nuclei. It recurred a second time, and now but few well formed spindle cells were found, but the tumour was chiefly composed of oval and flask-shaped cells, or rather masses of protoplasm, in which numerous nuclei
n of the spine of the scapula, removed with the
owth had sprung from the cancellous tissue.

mata, formerly often spoken of as fibro-plastic
the variety last described. They are usually
d dark-red in parts from extravasations

of blood, and if of any size, their central parts are opaque and yellow from the effects of fatty degeneration. They yield more or less transparent viscid juice on scraping, mixed with fragments of the growth. They may be distinctly circumscribed and encapsuled, but not unfrequently they invade surrounding parts. They often contain cysts of some size, sometimes filled with straw-coloured fluid and sometimes with blood or a blood-coloured liquid. These tumours frequently form in connection with bones, especially commencing under the periosteum of the shafts of long bones or about the bones of the face or nose. I once amputated a thigh at the hip-joint in University College Hospital, for a large tumour of this kind growing beneath the periosteum of the femur; and in another case the arm was removed by Heath for a similar growth. Both had caused spontaneous fracture of the bone, and both ultimately proved fatal from secondary internal growths. These tumours when affecting bone, must not be confounded with the myeloid, which they closely resemble. Large-spindle-celled sarcomata also grow in fasciæ and intermuscular spaces, and not unfrequently in glands, especially the mamma; and they may be found in rare cases in almost any situation. They very often run a malignant course, giving rise to secondary growths in internal organs. Their tendency to local recurrence after removal is very great.

From what has been said above, it will be seen that the spindle-celled sarcomata form a very large and important group of tumours, varying greatly in clinical characters and structure, but all resembling each other in the broad feature of the spindle cell forming the predominant element. As to their *prognosis*, it may be stated generally that the more they approach the structure of the spindle-celled growth found in cicatrizing wounds, the less likely they are to give rise to general infection of the system; but that even the simplest may recur locally after removal, and consequently too guarded a prognosis cannot be given in such cases.

Oval-celled Sarcoma (Fig. 378) may be looked upon as merely an extremely rapidly growing and malignant spindle-celled tumour. Thus we saw in the case above mentioned, that, as the rapidity of the growth increased with each recurrence, the spindle cells were replaced by large oval cells with two or more nuclei. But similar growths may occur primarily. They are soft, rapidly growing, rarely completely circumscribed. They are of a delicate pinkish colour, and yield an abundant slimy albuminous fluid on section. I have twice had occasion to remove such growths from the neighbourhood of the mamma. In one case the disease recurred locally after the wound had healed, and in a short time formed an enormous tumour, larger than the patient's head. She refused a second operation, and the case soon terminated fatally. In the other, although a large portion of the pectoral muscle was removed with the tumour, it recurred before the wound healed, and, in spite of the free application of caustics, grew with enormous rapidity, in a few weeks forming a fungating mass as large as a fœtal head.

Fig. 378.—Oval-celled Sarcoma. (188 diam.)

Myeloid or Giant-celled Sarcoma was formerly often classed under fibro-plastic tumours, and sometimes probably as soft cancer. It was described by Abernethy under the name of "albuminous sarcoma." It was first fully

described by Lebert, and its clinical and anatomical characters have been carefully investigated by Paget. It is nearly related to the spindle-celled group of sarcomata.

The most characteristic feature of myeloid tumours is the presence of large, many-nucleated masses of protoplasm—the so-called myeloid cells—somewhat resembling the cells found in the marrow of fœtal bones (Figs. 379, 380).

Fig. 379.—Myeloid Sarcoma from the Lower Jaw (454 diam.). The small cells have shrunk away from the myeloid cells; the former vary from round to spindle shape.

Fig. 380.—Constituents of a Myeloid Tumour (454 diam.).
a a'. From a fresh scraping.
b, *c*. From a stained section.
d. Transparent nuclei from a fresh scraping.

They are often of great size, sometimes $\frac{1}{100}$th or even $\frac{1}{50}$th inch in diameter, and extremely irregular in shape, having processes projecting from them in all directions. The nuclei vary from eight or ten to thirty or forty in number, and are oval in shape, with distinct and highly refracting nucleoli. These myeloid cells are imbedded in masses of spindle-shaped or roundish cells, between which there is either no intercellular substance, or merely a small quantity of homogeneous gelatinous material. These growths are extremely vascular; so much so, that the whole mass may pulsate distinctly. Myeloid tumours frequently contain cysts, often of considerable size. On section they present a soft gelatinous appearance and brittle structure; they usually yield a slimy fluid on scraping, mixed with fragments of the tumour; they are of a pink colour at their growing margin, while the central parts are of an opaque yellow from fatty degeneration. The intermediate parts usually present patches of a dark maroon colour, caused by extravasation of blood. Occasionally patches of ossification may be found. Myeloid tumours grow almost exclusively from bone, and by far most frequently from the medullary cavity or cancellous tissue at the head of a long bone. They attain a large size, sometimes slowly and gradually, and at other times with very great rapidity. The growth gradually causes absorption of the bone, but at the same time a new deposit takes place from the periosteum, so that the tumour

Fig. 381.—Myeloid Tumour of Radius.

is enclosed in a thin bony shell, which, on pressure, yields the peculiar sensation known as "egg-shell crackling." On reaching a cartilage-covered surface it pushes the cartilage before it, but rarely if ever perforates it. On examination of such a tumour after removal, a bony plate will frequently be found separating it from the medullary canal. In other cases it may extend a long distance, infiltrating the medulla. Myeloid tumours are most common at the lower end of the femur, the upper end of the tibia, and the upper end of the humerus. They also, when growing from the jaw-bones, form one variety of epulis. I have removed them from the lower end of the radius, and from the metacarpal bones (Figs. 381, 382). In the majority of cases they may be safely removed without the prospect of recurrence, but occasionally they return after removal. The true myeloid rarely, if ever, gives rise to secondary deposits in the lymphatic glands or internal organs. Myeloid tumours are said to have been seen in the parotid region and the mamma, but this is doubtful.

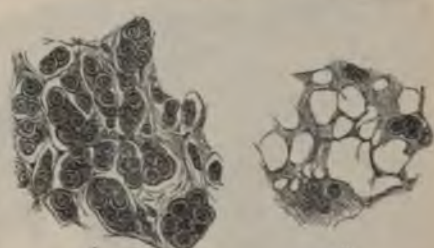
Fig. 382.—Myeloid Tumour of the Metacarpal Bones of the Index and Middle Fingers. Successful Removal of those Bones and Fingers.

Ossifying and Osteoid Sarcomata.—These tumours were formerly classed amongst the cancers, under the name of "osteoid cancer." Almost any form of sarcoma may undergo ossification. Thus round-celled, spindle-celled, and myeloid sarcomata may occasionally show abundant formation of bone. The development of bone in these growths seems to give rise to no radical change in their nature. They still show the same tendency to unlimited growth and sometimes the same liability to recur locally or to give rise to secondary deposits in distant parts. The secondary deposits develop bone like the original growth. The bony parts of these tumours usually present the appearances of true bone, but somewhat irregular in structure. Occasionally tumours growing from bone are met with, which present the structure of the growing tissue found beneath the periosteum in inflammation or in normal growth; that is to say, small round or polygonal cells (osteoblasts), with single nuclei, separated by a small amount of homogeneous or fibrillated intercellular substance. These are arranged in a layer on laminæ of newly formed bone. Sometimes the whole growth may resemble a mass of callus. These *osteoid sarcomata*, as they have been termed, form under the periosteum, and the bone beneath is often thickened, so that the medullary canal may be obliterated. They show a considerable tendency to local recurrence after removal. In rare cases, ossifying sarcomata are found unconnected with pre-existing bone.

The **Chondrifying Sarcoma or Chondro-Sarcoma.**—These tumours were formerly classed with chondromata, and were regarded as malignant cartilaginous tumours. Microscopic examination, however, shows that their growing margin is distinctly sarcomatous, composed most commonly of spindle-shaped or round cells. These become separated by a homogeneous ground-substance forming the matrix of the cartilage, the cells remaining as cartilage cells. Irregular patches of ossification may be scattered through the growth. These tumours are not circumscribed, the sarcoma tissue invariably invading

neighbouring parts. They commonly run a malignant course, and the secondary tumours may show the same tendency to the development of cartilage. They are met with almost exclusively in connection with bone, and most commonly commence under the periosteum of one of the long bones near its articular end. They are also not uncommon in the upper and lower jaw, and are occasionally seen in the testicle. They are distinguished from simple chondromata by their more rapid growth and their tendency to invade surrounding parts.

Alveolar or Large-Round-celled Sarcoma.—In this rare tumour, which was first clearly described by Billroth, the cells are of considerable size, sharply defined, and each contains a large round nucleus (Fig. 383). They thus closely resemble epithelium cells in appearance. They are separated from each other by a distinct and somewhat abundant fibrous stroma, but on careful examination this will be found to penetrate between the individual cells. In some parts, probably from the pressure of the growing cells, the stroma may be partially absorbed, so that the cellular elements seem to lie in alveolar spaces in immediate contact with each other, but further examination of the tumour will always show parts where the stroma and cells are closely intermixed. On carefully pencilling out the cells from a thin section, a delicate stroma is brought into view, passing between the individual cells and subdividing the spaces formed by the bands, which give the growth its alveolar and cancer-like appearance (Fig. 383B). In some cases, however, the distinction between these tumours and scirrhus is very difficult. Alveolar sarcomata occur chiefly in the cutis, bones, and muscles, and occasionally in the breast. In the cutis they form hard rounded tumours, often multiple, of tolerably slow growth, and free from pain. They lead ultimately to ulceration of the skin and the formation of an intractable sore. In the bones, they are more often single and of more rapid growth. Three cases affecting the cutis have occurred in University College Hospital during the last few years. In the first, three amputations were performed for recurrence of the growth after removal, by Christopher Heath, commencing with one finger and ending with the forearm. The tumour, when first removed, was supposed to be a specimen of scirrhus of the skin. Finally similar tumours appeared on the cheek and scalp, and two further operations were performed. The man died shortly afterwards, and there was reason to believe that the cause of death was a similar growth in the lung. The whole history of the case lasted more than seven years, and at no time had the lymphatic glands been affected. In the second case, Berkeley Hill amputated the leg for a number of similar tumours situated below the knee, from one of which the accompanying drawing (Fig. 383) is taken; and in the third, half the foot was amputated for a similar growth, which commenced at the roots of the second and third toes, and had recurred three times after removal.



A B

Fig. 383.—Alveolar Sarcoma from Skin of Leg (188 diam.).

A. To show general arrangement.

B. After prolonged pencilling shows the intercellular as well as the alveolar stroma.

Plexiform Sarcoma or Cylindroma.—A rare form of tumour has been described by Billroth, Sattler, and others, under this name. It consists of small cells of a polygonal form arranged in cylinders communicating with each other in a plexiform manner, between which is a varying quantity of hyaline, or finely fibrillar connective tissue. Knob-like projections or globe-like masses of the cells are also met with. The individual cells are in immediate contact with each other, without any apparent intercellular substance. The peculiar appearances are supposed to be due to a hyaline or mucoid degeneration of the walls of the vessels and the neighbouring cells of the tumour. The remaining cells are squeezed together, and thus assume the form of columns of polygonal cells. Great doubt exists, however, as to the exact mode of origin of these growths. At first sight a microscopic section of a plexiform sarcoma closely resembles that of an epithelioma, but a careful examination with a higher power shows its true nature. The tumours seldom reach any great size. They are soft and gelatinous, and of a dirty white colour. They are most commonly met with in the brain, the orbit, and sometimes in the salivary glands. Butlin has recorded a case in which the tumour formed in the popliteal space. It recurred after removal, and its true nature was shown by the fact that the recurrent growths assumed the form of the ordinary round-celled sarcoma.

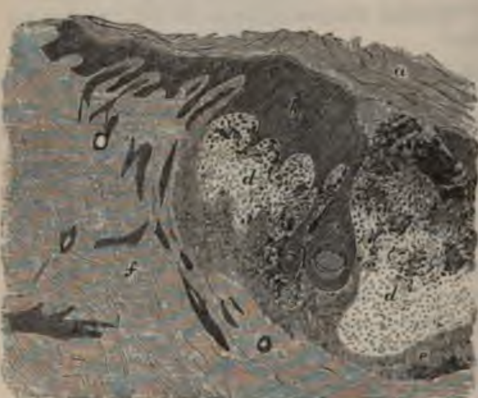


Fig. 384.—Melanotic Sarcoma commencing in the Papillæ of the Skin (Malignant Mole.). (40 diam.)
a. Superficial epidermis.
b. Deeper layers of Epidermis, which is deficient to the right of the drawing.
c. Prolongation of the Epidermis into the centre of the growth.
d. Sarcoma tissue, chiefly non-pigmented but with scattered melanotic patches.
e. Connective tissue round the tumour infiltrated with small round cells.
f. Surrounding connective tissue with vessels.

Melanotic sarcoma is usually of the spindle-celled variety, but frequently contains large numbers of round or oval, intermixed with the fusiform, cells (Fig. 384). The spindle cells are of large size, and there is no fibrous stroma between them. More rarely it presents the structure of an alveolar sarcoma. The pigment is seen as brownish granular matter in the interior of a certain number of the cells, the rest remaining colourless. The proportion of coloured cells varies in different specimens. In the secondary tumours, it has been shown by Godlee that the new cells follow the lines of the vessels. These tumours are usually sharply circumscribed, both to the naked eye and the microscope. They are soft, sometimes almost pulpy, round or oval in shape, and vary in colour from dark brown to the most intense black. They arise especially from structures in which pigment naturally exists, namely, the skin (Fig. 384) and choroid coat of the eye (Fig. 386). They appear, however, occasionally to arise primarily in the lymphatic glands, and primary melanotic sarcoma of the liver has been recorded. They are of rapid growth, and occur usually in middle life. Melanotic sarcoma is one of the most malignant of all

forms of tumour. The secondary growths occur in every organ and tissue of the body, and they may apparently be propagated entirely by the vascular system, the lymphatic glands escaping any contamination, or they may be distributed by both the vascular and the lymphatic systems. It may be broadly stated that if a melanotic sarcoma reach the size of a filbert, secondary deposits have in all probability occurred, and no local treatment can cure the patient, although, by relieving him of one source of infection, it may retard death. Although showing this terrible general malignancy, the local malignancy of melanotic sarcoma is not great. It may reach a large size without ulcerating; it is frequently distinctly encapsuled, and, if removed freely, often does not return in the scar. The secondary tumours form in every part of the body; constantly in the lungs and liver, almost constantly in the brain and spinal cord, spleen, kidneys, and subcutaneous tissue; very often in the heart, intestines, medulla of bones, and lymphatic glands. Like the cells of the primary tumour, some of the secondary growths are found to be pigmented and some not. The *diagnosis* of melanotic sarcoma is made by

Fig. 385.—Melanotic Sarcoma, from a Secondary Tumour in the Heart. Figure to left (188 diam.) shows the different degrees of pigmentation and variety of shape in the different cells. Figure to right (454 diam.), from a fresh scraping, illustrates the differences in the size of the pigment granules.

Fig. 386.—Melanotic Sarcoma of Eye—natural size. The eye has been divided in the antero-posterior diameter. The tumour started from the choroid and afterwards burst through the sclerotic.

the colour and rapidity of the growth. It must not be confounded with the simple pigmented wart. This is always of slow growth, more or less firm, pedunculated and lobulated. It must be remembered, however, that melanotic sarcoma may start from a wart of this kind, or from a congenital mole. As to true melanotic cancer, that is to say pigmented encephaloid or epithelioma, it is doubtful if such a growth exists; at any rate, it must be of extreme rarity. The only *Treatment* of melanotic sarcoma is the immediate removal of the tumour, unless secondary tumours can already be recognized.

Psammoma is a rare form of tumour found only in connection with the membranes of the brain. The chief characteristic of this growth is the presence of small concentric calcareous globules, the so-called "brain-sand." The tumour is composed chiefly of peculiar flattened cells. It gives rise to no symptoms, except in infinitely rare cases.

Sarcomatous Blood-cysts or Hæmatomata.—Tumours have frequently been described under the name of "blood-cysts," of which the most characteristic feature is the presence of a large collection of fluid or partly coagulated blood in a cyst, the walls of which are imperfectly defined. If the blood is evacuated by puncture or incision, free hæmorrhage, difficult to

control, or, at least, speedy re-accumulation of the fluid, is the only result. If seated on a limb, free excision of the cyst and its contents, or amputation, is justly looked upon as the only mode of treatment holding out any prospect of success. With regard to the nature of these tumours, it has been shown that in all probability they are, in the great majority of cases, soft sarcomata, broken down by hæmorrhage into their structure. The walls of these cysts are formed of a thin layer of sarcoma tissue, either of the round or spindle-celled variety. A very interesting case of this kind came under my care in University College Hospital in 1874. A healthy man, aged 40, had noticed, for about nine months, a soft swelling on the upper and outer part of the leg, which he attributed to a strain. It fluctuated distinctly; and when I first saw it, a dark red fluid was oozing from two discoloured points. It was altogether about three inches in diameter, and of a dark purple colour. It had previously to admission been treated, first by the passage of a seton, and secondly, by being laid open and dressed from the bottom; which latter treatment had been repeated twice. On both occasions it was reported that nothing but blood escaped. I laid the tumour freely open, and turned out a large quantity of what was apparently ordinary blood-clot and then dissected away the cyst-wall. The supposed blood-clot was found, on microscopic examination, to be composed of a mixture of the cells of a round and spindle-celled sarcoma, with coagulated blood (Fig. 387). The wall of the cyst was found to be composed of pure sarcomatous tissue. The growth recurred before the wound was completely closed, and amputation at the knee-joint was performed, the patient making a good recovery.

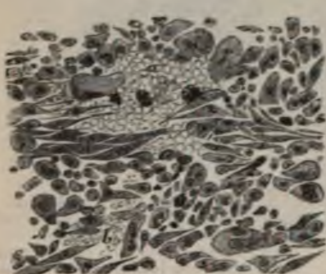


Fig. 387.—Mixed Round and Spindle-celled Sarcoma, into which Hæmorrhage has taken place (188 diam.).
a. Recent Hæmorrhage.
b. Blood-corpuscles becoming granular.

Mixed Sarcomata.— Tumours are frequently seen which combine in themselves structures properly belonging to two or more distinct forms of growth. Several of these have already been mentioned. Thus the growths standing on the doubtful line between small-spindle-celled sarcoma and fibroma are spoken of as *fibro-sarcomata*. In very rare cases some of the cells of a sarcoma may develop into true fat cells; we have then the *lipo-sarcoma*. Occasionally large tracts of a tumour, the chief part of which is purely sarcomatous, may undergo mucous softening, and the cells may be more or less stellate or branched, as in a myxoma, and we have then the *myxo-sarcoma*. As before stated, the tissue between the acini of an adenoma may present exactly the structure of a spindle-celled or even round-celled sarcoma; these tumours are then sometimes called *adeno-sarcomata*. Lastly, the stroma of a cancer may be composed of cells like those of a large-spindle-celled sarcoma. In tumours which are purely sarcomatous it is, moreover, very common to find a mixture of the various kind of cells which have been described as characterizing the different varieties mentioned in the preceding pages.

V. TUMOURS COMPOSED OF CELLS OF AN EPITHELIAL TYPE ARRANGED IN SPACES IN A STROMA CONSISTING OF MORE OR LESS PERFECTLY DEVELOPED FIBROUS TISSUE.

The members of this group constitute the **Carcinomata** or **Cancers**, and are uniformly malignant. Before proceeding to the individual growths forming this class, it will be desirable to say a few words upon the subject of cancer generally. The term has been very vaguely applied, the older pathologists placing under this class all malignant growths; thus all malignant sarcomata were formerly considered to be cancers. Statistics and general statements with regard to "cancer" which date back beyond 1870 must therefore be taken to refer to malignant tumours in general and not to what we now recognize as true cancers.

Although the various forms of cancer differ greatly from each other in structure, they all possess certain features in common. The essential element of every cancer is an exuberant growth of epithelium. Every exuberant growth of epithelium is not, however, a cancer. The distinguishing feature of carcinoma is that the epithelium no longer merely covers a surface or lines the acinus of a gland as in its normal state, but forces its way into deeper structures or surrounding parts. The advancing cells form bud-like processes or columns which communicate with each other by lateral branches. At the growing edge of any cancer these processes of cells can be seen advancing into the spaces of the tissue into which the growth is spreading. The pressure of the new growth, and possibly some chemical substance derived from it, irritate the surrounding tissues to such a degree that they become infiltrated with small round cells. These have all the appearances of migrating white corpuscles, but it is not impossible that they may in part arise from multiplication of the cells of the connective tissue. In some forms of cancer in which the epithelial cells are small and rounded, it is not easy to distinguish these from the surrounding small round cells, and thus there has been much diversity of opinion as to the origin of the cells of cancer; but in other varieties, as the squamous carcinoma, the different forms of cells are easily recognized, and in these there can be no doubt that the cancer cells arise from the pre-existing epithelium. If we examine a portion of a cancerous tumour, in which the structure is fully developed, we find that the original tissues of the part which has been invaded by the growth have disappeared during the process of small round cell infiltration, and that a new connective tissue has been formed which surrounds the branching columns of epithelium cells. We have thus developed an alveolar stroma, the spaces of which are filled with cells of an epithelial type, and this forms the characteristic structure of a carcinoma. The fibrous stroma must be looked upon as an essential element in the structure of the growth, and not merely as the remains of the connective tissue of the part which the cancer cells are invading. As in normal glands or epithelium-covered structures, the line of demarcation between the epithelium and the stroma is sharply defined; the cells lie closely in contact with each other without vessels or stroma penetrating between them. They are but loosely connected with the stroma and with one another, and in many cases are separated from each other by a very small quantity of fluid. If a thin section of a carcinoma be gently brushed under water with a camel's hair pencil, or shaken in a test-tube half full of water, the cells may be washed away and the stroma

left. Its alveolar nature will then be distinctly apparent, and the fibrous stroma will be seen to bound spaces which by their communication form a cavernous system.

The stroma is composed of coarse fibres, sometimes almost hyaline in appearance. Between the fibres are flattened or elongated cells, like ordinary connective tissue corpuscles. In some cases it is less perfectly developed, and may contain numerous small round cells, or even be composed almost entirely of spindle cells. The vessels traverse the stroma in all directions. They vary much in number and size. In some very rare forms of cancer they are so abundant that the whole growth may pulsate ; in others they are comparatively scanty. In all cancers as the growth advances the vascular supply becomes insufficient to maintain the vitality of the central parts of the tumour, and fatty degeneration, first of the cells and subsequently of the stroma, takes place. If the tumour is superficial the tissues break down, and ulceration results.

The process above described is now acknowledged to be that by which cancer arises and spreads. It was first clearly described by Thiersch and Waldeyer. It explains the fact, that primary cancer never arises except in connection with pre-existing epithelium. The branching columns of cells probably invade the surrounding tissues by the lymphatic spaces and vessels. The proliferating epithelium, having burst through the wall of the acinus when the disease commences in a gland, or having forced its way into the deeper parts when it starts from a surface, enters the lymph-spaces and grows into them. This view is confirmed by the general arrangement of the epithelial columns, and Waldeyer believes that he has demonstrated lymphatic endothelium lying on the surface of the advancing processes of epithelium. It also explains the great readiness with which carcinoma infects the lymphatic glands. The microscopic appearances of the tissues surrounding the advancing columns of cells are identical with those of inflammation. The vessels are dilated and full of blood, and the normal structures are concealed by an abundant small cell infiltration before which the original tissues disappear as in the process of ulceration. The quantity of lymph returning from the hyperæmic tissues will necessarily be greatly increased in quantity, and the lymph-spaces and lymphatic vessels will be dilated, and thus the dissemination of the cells of the cancer will be greatly facilitated should any of them become disengaged from the general mass and enter the lymph-stream.

From the above remarks it will be seen that a carcinoma is characterized by the absence of any definite surrounding capsule. It is indeed intimately connected with the tissues in which it lies, and around the tumour there is a zone of variable extent in which infiltration is progressing but which to the naked eye does not necessarily appear to be diseased.

The cells of a carcinoma always more or less accurately resemble those of the normal epithelium of the part from which the primary tumour springs. Thus the cells of carcinoma of glandular organs belong to the type of spheroidal or glandular epithelium ; those of the skin are squamous, and those of the intestine columnar. In rapidly growing cancers or secondary growths the cells may show a tendency to revert to the primitive type of epithelium, a simple rounded or irregular cell with a large oval nucleus. Thus the cells of a rapidly growing squamous carcinoma may be oval, or even rounded, and show but little flattening, or in a columnar carcinoma they may be shorter and oval and lose their wedge-shaped form. Still, in the great majority of cases,

there is no difficulty in recognizing the type to which the cell belongs. In other cases the cells may be larger and show a more exuberant growth than the normal epithelium, but their general characters remain the same. The old idea that there existed a peculiar specific "cancer cell" is now completely abandoned, and it is universally recognized that no certain opinion can be pronounced as to the cancerous nature of a tumour without a careful examination, not of the cells only, but of the stroma, and of the relation of the cells to the stroma. The cells of all cancers are prone to early fatty degeneration. In some forms they undergo a colloid change.

Varieties of Carcinoma.—Cancers are classified primarily according to the variety of epithelium that enters into their composition, and certain subdivisions are made according to the modifications in the stroma or in the mode of growth of the tumour. The following classification is that usually adopted :—

1. Cancers the cells of which are derived from glandular or spheroidal epithelium. *Spheroidal or Glandular Carcinoma.*

a. With abundant dense stroma. *Scirrhus*, or Hard Cancer.

b. With a small proportion of stroma forming large alveolar spaces. *Medullary, Encephaloid, or Soft Cancer.*

c. One of the above forms (*a* or *b*), with colloid degeneration of the cells. *Colloid Cancer.*

2. Cancers the cells of which are derived from squamous or stratified epithelium. *Squamous Carcinoma.*

3. Cancers the cells of which are derived from columnar epithelium. *Columnar Carcinoma ;* sometimes also called inaccurately *Adenoid Cancer.*

The above form the typical and universally recognised varieties of cancer. There are, however, two other morbid growths which must be included in the same class : thyroid cancer and rodent cancer, or as it is more commonly called rodent ulcer.

Thyroid Cancer is an extremely rare malignant growth, commencing in the thyroid body and closely resembling the normal gland tissue in structure. It gives rise to secondary growths in the lymphatic glands, the lungs, and the bones, accurately repeating the structure of the primary growth. (See Diseases of the Thyroid Body, Vol. II., Chap. LV.) Its general malignancy forms the most marked feature of the disease.

Rodent Cancer or Ulcer is a cancer in structure, being composed of columns of epithelial cells in a very imperfectly developed stroma, like a true carcinoma. Its malignancy is, however, purely local, and although it slowly invades and destroys every structure with which it comes in contact, it never gives rise to any secondary growths. (See Rodent Ulcer, Vol. II., Chap. XXXVII.)

The special clinical and pathological features of the various forms will be considered after the general facts which are common to all varieties.

Secondary Carcinomatous Growths.—The most marked feature of a cancer is its tendency to give rise to secondary growths of a similar nature in various parts of the body. These may occur in three situations. First, in the lymphatic glands which receive the lymph from the affected part ; secondly, in the cellular tissue in the immediate neighbourhood of the growth ; and thirdly, in distant parts, especially in internal organs. The secondary growths always resemble the primary growth in structure. The secondary tumours from a glandular cancer contain glandular epithelium, those from a squamous

carcinoma, squamous epithelium, and those from a columnar carcinoma, columnar epithelium. The epithelium may be slightly modified from growing in a situation where it is far less exposed to surrounding pressure, or more abundantly supplied with blood, but its general characters always remain the same. In like manner the stroma of the secondary growth may be less abundant than that of the primary, and may thus cause some modification in the consistence of the tumour; but the broad fact remains—that the secondary tumours are of the same structure as the primary.

The mode of origin of the secondary tumours has given rise to much diversity of opinion. The view now usually accepted is that the secondary growths arise from the entrance of the cells of the cancer into the lymphatics or blood-vessels, by which they are carried to distant parts, and there lodging develop into tumours of the same nature as that from which they sprung. According to this theory, the cells of the new tumour are the descendants of the original cell which started from the primary growth. Simon, Creighton, and others believe that the new growth arises from the cells of the part in which the cancer cell has lodged, and upon which it exerts what they term a "spermatic influence," but this view is not generally accepted. The view of the direct transference of the cells of the tumour to different parts of the body is known as the *implantation theory*. Opposed to it is the *infection theory*, according to which the system is poisoned by the juices of the primary growth. There is yet another theory maintained by those who believe cancer to be a primary "disease of the blood," of which the tumour is merely the local manifestation. Those who hold this view believe that the secondary growths are merely a further effect of the constitutional condition from which the primary growth originated. Thus Paget is of opinion that in some cases, in which a rapid multiplication of cancers takes place, this may arise from an increase in the cancerous diathesis or morbid condition of the blood. But he believes that in most of these cases there has been a conveyance of cancerous material by the blood, in the form of emboli, which have determined the local seat of the secondary growth; and he supports this view by referring to the analogy pointed out by Walshe as existing between the secondary deposits in cancer and the secondary abscesses in pyæmia; the liver and lungs in both cases being principally affected. He, however, thinks that it is not necessary to suppose that entire cancer cells are thus transferred: cancer juice, or minute fragments of cancer-plasma, may be as efficient as entire cells. Virchow considers that the fact that the secondary deposit does not necessarily occur in the organ through which the blood must first pass, militates against the theory that cancer cells are carried onward by the circulation, and become impacted in the smaller vessels of the part, in the manner of emboli. He inclines to the belief that the cancerous juices are absorbed and enter the circulation either directly by the veins or indirectly through the lymphatics, and that they give rise to changes in the nutrition of certain parts, leading to the development of cancerous growths.

In favour of the simple transplantation theory is the important fact that in the secondary growths epithelium arises in situations in which it is not normally present, as in the lymphatic glands and bones; and when the growth is situated in an organ in which epithelium is normally present, as in the liver or kidney, the cells of the new growth are not those natural to the organ, but correspond to those of the primary cancer. Thus the tumours in the liver secondary to

cancer of the great intestine have shown distinct evidence of their origin in being composed of a structure resembling in appearance the crypts of Lieberkühn. That the cells may pass along the lymphatics is sometimes shown by finding lymphatic vessels distended with nodules of cancerous growth. It is difficult to imagine juice or granular *débris* which could cause the development of glandular epithelium in bone or columnar epithelium in the liver.

The fact that the secondary growths do not invariably arise directly in the course of the lymph or blood-stream—as for instance when secondary tumours are found in the liver or bones and not in the lung—may be explained by supposing that the transplanted cells do not grow with equal facility in all structures. The experiments of transplantation of one kind of tissue into another, as of periosteum into the subcutaneous tissue, have shown that although it may grow for a time, it eventually perishes and is absorbed. This power shown by a tissue of resisting the growth of a foreign structure within it is called by Cohnheim *the physiological power of resistance of the tissues.* Cohnheim therefore assumes that in cancerous subjects this resisting power is diminished, possibly in consequence of the poisoning of the system from the primary growth, or as a part of some constitutional condition which predisposed to the development of the original tumour, and that this plays as important a part in the development of secondary growths as the transplantation of cells. Against the theory that the secondary growths are entirely the result of some constitutional condition which gives rise also to the primary growth it may be urged that, if this were the case, the secondary tumours would appear in the favourite seats of the primary growth, and that each tissue should produce the form of cancer natural to itself, which, as we have seen, is the reverse of that which really occurs.

Some forms of cancer show a much greater power of reproduction than others. Thus glandular cancers recur rapidly throughout the body, while squamous carcinoma seldom infects beyond the nearest lymphatic glands. Whatever may be the exact mode of formation of the secondary growths, the balance of evidence may be said to be greatly in favour of some form of the transplantation theory, and therefore we may hope that, if the tumour could be removed sufficiently early, dissemination of the disease might be prevented. The theories here put forward with regard to cancer apply equally to the malignant sarcomata.

General Clinical History of Carcinoma.—All forms of cancer present numerous points of resembance in their progress. When once formed, the tumour continues progressively to increase in size, with a degree of rapidity, and to an extent, that vary according to its kind. Its growth is usually accompanied by pain, varying with the situation of the tumour and its variety. When the tumour has reached a certain size, the process of decay commences in the central parts, while growth continues at the circumference. The mass softens at some point, the skin covering which becomes duskily inflamed and ulcerated, and an irregular sloughy aperture forms, through which the *débris* of the mass are eliminated in an ichorous or sanious fluid, having often the peculiar fœtid smell usually accompanying the putrefaction of epithelium. The ulcer then rather rapidly increases, with raised and everted edges, a hard and knobby, or soft and fungating surface, and the discharge of a dark fluid, often attended with hæmorrhage, and occasionally with sloughing of portions of the mass at an early period. The pain in the tumour usually

becomes more severe during ulceration. The lymphatic glands are affected most commonly at an early period in the case, but sometimes not until after ulceration of the cancer has commenced. In external cancers, such as come under the care of the Surgeon, the general health as a rule suffers but little until the presence of the foul ulcerating sore gives rise to chronic septic poisoning, or to exhaustion from pain and want of rest, and sometimes also from loss of blood. In fact at the time the patient first presents himself he is often in the rudest health except for the local disease. In cancers of internal organs, and in the later stages of external cancers when secondary internal growths have formed, the general health becomes gravely affected, and the condition known as the *cancerous cachexy* is developed. In this cachexy the countenance is peculiarly pale, drawn, and sallow, so that the patient has a very anxious and care-worn look. The general surface of the body commonly acquires an earthy or yellowish tint, and not unfrequently large spots of chloasma make their appearance on various parts of it; the appetite is impaired, the voice enfeebled, the muscular strength greatly diminished, and the pulse weak. The patient complains of pains in the limbs, of lassitude, and of inability for exertion, and he emaciates rapidly; and at last dies from exhaustion, induced by the conjoined effects of weakening discharges, general debility, and pain. Various views have been held concerning the nature of this cancerous cachexia. It has been assumed that it is an indication of a constitutional condition or blood-disease of which the tumour is merely a local manifestation. It has also been suggested that it may be due to the entrance into the blood-stream of some noxious material generated in the cancerous growth; and lastly, that it is merely the effect of the pain of the tumour, the want of rest, the exhausting discharges, and the implication of important internal organs by secondary growths. The first theory is negatived by the fact that cachexia is certainly wanting in the early stages of all external cancers, and in squamous carcinoma is often absent till near the end of the case. The second theory is a pure hypothesis; and the last is therefore that which seems most worthy of acceptance.

Causes.—The causes of cancer, as of all other diseases, may be divided into two great classes, viz.: the constitutional or predisposing, and the local or exciting.

Constitutional or Predisposing Causes.—It is difficult to connect any distinct or recognizable constitutional condition with a tendency to this disease. Cancer, indeed, commonly shows itself in persons apparently in perfect health, of florid complexion, and robust habit of body.

The *hereditariness* of cancer has, however, been established beyond a doubt. Velpeau states, as the result of his researches, that it is traceable hereditarily in one-third of the cases. Paget, amongst hospital patients, found evidence of hereditariness in about 1 in 6, but amongst private patients, whose family histories are better known, it amounted to 1 in 3; thus agreeing with Velpeau's estimate.

The hereditary tendency is in some cases not only to cancer generally, but to the same form of cancer. Thus, Paget records a case in which three generations were affected by uterine cancer. Sibley records an instance in which a mother and five daughters suffered from cancer of the left breast. It is not, however, by any means always so. Paget states that it is only in about one half of the cases of hereditary cancer that it is thus transmitted, and then almost exclusively in the breast and uterus. He relates one striking instance

of the opposite mode of transmission. A lady died of cancer of the stomach; one of her daughters died of cancer of the stomach, another of cancer of the breast; and of her grandchildren, two died of cancer of the breast, two of cancer of the uterus, one of cancer of the bladder, one of "cancer of the axillary glands," one of cancer of the stomach, and one of cancer of the rectum. The hereditary tendency transmitted from parent to offspring would seem therefore to be not purely local, as in the case of a peculiar feature, a fifth finger, or the like, but to affect the whole of the epithelial tissues, the particular spot at which the cancer appears being dependent on local causes usually unknown. Admitting the hereditary nature of cancer to the fullest extent, however, it still leaves two-thirds of the cases unaccounted for.

Age exercises a marked influence on the occurrence of cancer, both as to its frequency and its mode of growth. The statistics published before 1870 in this country, and perhaps a few years earlier in Germany, cannot be relied upon as giving a just notion of the influence of age on the occurrence of true cancer. Before that time all soft rapidly growing sarcomata were described as cancers. The malignant glioma of the eyeball, and sarcomatous tumours of the testicle and bone, being formerly classed as encephaloid cancer, that disease was said not to be uncommon in children. Now that these are excluded, all forms of cancer may be said to be almost unknown under 20. Gurlt, who possesses the patience and industry necessary for the collection of statistics to a degree rarely if ever equalled, has obtained from various sources the records of 16,600 cases of tumours of all kinds. Of these, 11,131 were cancers. In 4,769 cases of cancer, of which the age is recorded, only 0·4 per cent. occurred under the age of 20. As some of the statistics extend back to the year 1855, it is possible that even this number is in excess of the truth. In the opposite extreme of life there is no limit to the age at which cancer may occur. According to Walshe the proportion of deaths from cancer per thousand living at each age increases steadily up to 80. Gurlt shows that the absolute frequency of cancer reaches its maximum between 41 and 50, 31·68 per cent. of all cases occurring between those ages. Age influences also the liability to cancer in special organs. Thus, in extreme old age cancer of the breast is less common than in younger women, while old men are more liable to cancer of the bladder and prostate, and to squamous cancer of the lip. Thus, Walshe states that proportionally to the number living, cancer is more common in men than in women after 80. Sibley states that the average age of patients with uterine cancer is 43, and with mammary 48 years. The age of the patient exerts a considerable influence on the rate of growth and malignancy of the tumour. As a rule, the younger the patient, the more rapidly does the tumour grow, the earlier does it affect the lymphatic glands, and the more widely disseminated are the secondary growths. This rule has, however, many exceptions.

Statistics tend to show that there has been a steady increase in the mortality from cancer during recent years. According to Spencer Wells the deaths from cancer in England and Wales numbered 7,245 in 1861 or 360 per million, whilst in 1887 the deaths were 17,113 or 606 per million. Such statistics doubtless include many cases of sarcoma, but putting aside various possible sources of error I have no doubt that the disease is on the increase.

Mental Emotions of a depressing character, if long-continued or frequently repeated, may possibly predispose to the occurrence of cancer. I have seen so many cases of cancer, more particularly of the abdominal organs, in

persons who have suffered much from grief or anxiety of mind for years before the development of the malignant disease, that, although the doctrine is incapable of proof, I cannot but look upon it as probable that the cancer was the result of the antecedent long-continued mental disquietude. We know, by every-day experience, that functional derangement of the abdominal and pelvic organs of the most inveterate character may be occasioned by mental disturbance; and it appears to me not improbable, that such functional derangement may at last lead to perversion of nutrition, terminating in malignant growth in such organs, as the uterus, the liver or the stomach, as are more readily influenced by the condition of the patient's mind.

Sex.—The influence of sex is well marked, not only in the absolute frequency of cancer, but in its occurrence in organs that are special to each sex. Cancer is absolutely far more frequently met with in women that in men, simply because cancers of the uterus and mamma constitute by far the largest proportion of these diseases, being infinitely more common than cancers of the male organs. But when we come to cancers of organs that are common to both sexes, as the tongue, the lip, the intestinal tract, &c., we shall, I think, find that they are more frequent in men than in women; the difference, however, not being sufficient to counterbalance the preponderance in the female reproductive organs. Von Winiwarter states, that in Billroth's hospital and private practice from 1867 to 1876, 278 cases of cancer of the skin and mucous membrane of the face and mouth came under observation. Of these 226 were men, and 52 women.

Exciting Causes.—The nature of the essential cause of carcinoma is not known. It is, however, certain that direct external violence, and more especially long-continued irritation of a part, often stand in some important relation to the development of the disease.

A blow on, or other injury of a part, often appears to be the direct determining cause of the development of a primary cancer. Scirrhus of the mamma is commonly attributed by the sufferer to the infliction of an injury. Long-continued irritation of a part also may cause a cancer to develop. This is a matter of every-day observation in the development of cancer of the tongue from the persistent irritation of a broken or jagged tooth, or the production of cancer of the lip by the constant use of an unprotected clay-pipe. But, perhaps, the most marked instance is that of the cancer of the scrotum in chimney-sweeps, developed by the irritation of the soot lodged in the rugæ of the part. Butlin brings forward three reasons for believing that in this case the soot itself is really the determining cause of the tumour: first, that in two recorded cases cancer has occurred on the hand in persons habitually handling soot; secondly, that other equally dirty trades do not cause it; and thirdly, that a warty condition of the skin is often met with in parts with which the soot comes in contact. Workers with coal-tar, and crude paraffin also show some liability to the same disease.

Local irritation is more likely to produce cancer if it be applied to a part that has already been for some time the seat of structural epithelial change. Thus, in a common wart, mole, or cicatrix, cancerous growths are very apt to develop under the influence of persistent irritation.

Every part of the body in which epithelium (as distinguished from endothelium) is naturally present is liable to become the seat of cancer. But

it occurs more frequently in some parts than in others. In the female it is most common in the mamma and uterus; in the male, epithelioma of the lip, tongue and penis is the most common form of the disease. In the alimentary canal it is most common at the narrowest parts, which presumably are most exposed to mechanical injury. Thus commencing at the mouth we find the common situations of cancer are, the lip, the tongue, the fauces, the œsophagus behind the cricoid cartilage, the cardiac orifice and the pylorus. Then follows the small intestine in which the contents are fluid, and the diameter almost uniform, and here cancer is extremely rare. It is less rare at the ileo-colic valve, and becomes common at the sigmoid flexure, which is the narrowest part of the great gut and contains solid fæces. In the rectum it occurs usually where the gut is slightly narrowed as it passes through the recto-vesical fascia, and finally it is common at the anus. The form of cancer met with in all these places is dependent on the epithelium normal to the part. As far as the cardiac orifice it is squamous, at the cardiac orifice it is usually one form of glandular cancer, at the pylorus and as far as the anus it is columnar, and at the anus it is again squamous. It has been observed that in those organs which have an intermittent functional activity, cancer is more frequent.

Assuming it to be true that the development of carcinoma in a part may be determined by long continued irritation, it is by no means clear what share the irritation actually takes in causing the disease. Chronic irritation of a mucous or cutaneous surface, as well as of glandular organs, produces as one of its effects a proliferation of the epithelium of the part, and it is conceivable that under certain circumstances this proliferation may by gradual stages become an actual carcinomatous growth. There is, however, a gradually increasing belief that carcinoma is the result of some specific irritation of epithelium, probably by the growth of a parasitic micro-organism in it. If this be so, chronic irritation can no longer be looked upon as an exciting cause of cancer, but rather as a local predisposing cause; the epithelial changes which the irritation occasions being not an early stage of cancer, but rather a *precancerous condition*, that is a condition rendering the part favourable to the development of carcinoma.

It is impossible here to make more than very brief reference to the vast amount of investigation which has been carried out in recent years with the object of determining the essential cause of carcinoma. Many pathologists believe that cancer is an infective disease, and that the tumour is the result of an abnormal growth of epithelium excited by the local action of a specific micro-parasite. In searching for evidence in support of this hypothesis, three separate forms of investigation have been made: first, to determine the possibility of the experimental transmission of cancer from man to animals or from one animal to another; secondly, to endeavour to obtain artificial cultivations of living organisms from freshly removed carcinomatous tumours; and thirdly, to endeavour by various methods of preparation and staining to demonstrate the presence of parasitic bodies in the cells of the growth. Ballance and Shattock, in this country, have endeavoured by a long series of most carefully conducted experiments to transmit carcinoma from the human subject to the lower animals. Their results in this direction have so far proved uniformly negative. They transplanted portions of freshly excised malignant tumours, mostly carcinoma of the breast, into the peritoneal cavity, muscles and subcutaneous tissues of monkeys, dogs, rats and other animals.

Small portions of tumour were gradually and completely absorbed, whilst larger portions became surrounded by an inflammatory capsule and underwent coagulation necrosis. Some success has, however, attended the many attempts which have been made to transmit cancer experimentally from one animal to another of the same species. Hanau of Zurich transplanted fragments of a squamous carcinoma of the vulva of a rat beneath the skin of the scrotum of two other rats. In one case the experiment was followed by the development of cancerous nodules along the line of one vas deferens and in the omentum: in the other case a mass of growth formed in connexion with one epididymis. It must, however, be allowed that the successful transmission of cancer by transplantation cannot be looked upon as any proof of its infective nature, but only, as Shattock has pointed out, as an example of successful grafting.

The attempts which have been made to obtain artificial cultivations of living organisms from fresh carcinomatous tumours have almost uniformly failed to give any positive result. Ballance and Shattock have transferred fragments of fresh cancer into various solid and fluid cultivating media, which were kept for long periods at about the body temperature. In almost every instance no growth of micro-organisms occurred, the cultivating medium and the fragment of growth within it remaining sterile, and in some cases unchanged in appearance for several years. Little importance can be attached to the fact that in one or two experiments a growth of micrococci took place in solidified human blood-serum. In 1887 Scheuerlen stated that he had succeeded in obtaining an artificial cultivation of a bacillus from cancerous tumours, but the observation was afterwards proved by Baumgarten and others to be erroneous.

Microscopic examination has altogether failed to demonstrate the constant presence of any vegetable micro-organism in carcinomata, and indeed it is at the present time thought probable that the micro-parasite of cancer, if such exists, is more probably of the nature of a protozoon. This theory has been to a large degree suggested by the study of a very common and often fatal disease in rabbits, in which a marked proliferation of the epithelium of the bile-ducts is the most constant lesion. In an animal dead of the disease in question the liver is found more or less extensively infiltrated by small greyish-white tumours, varying in size from a pin's head to a pea. The microscope shows that the appearances are due to changes in the bile-ducts, which are dilated and occupied by branching papillary growths covered with proliferating epithelium. The disease is produced by a protozoon—the coccidium oviforme of Leuckart—which gains access to the body by the alimentary canal. The encysted form is found in large numbers as oval bodies (psorosperms) in and between the epithelium cells of the growths in the bile-ducts, whilst it is believed that a certain stage of development is passed outside the body. Darier and Wickham in France, and Bowlby and Hutchinson in this country, have described psorosperms in the epithelium cells in cases of Paget's disease of the nipple, an affection which certainly stands in an important relation to carcinoma of the breast (see Chapter LX., Vol. II.). It is, however, by no means certain that the bodies in question are really parasitic in nature. Of the many observers who in the last few years have described parasitic protozoa in the cells of carcinoma, may be especially mentioned Malassez, Russell, Soudakewitch, and Ruffer and Walker; the researches of the last-named observers have been confirmed by Galloway, and extended by Ruffer and Plimmer. Ruffer and

Walker describe round bodies in the epithelium cells, varying from 0.004μ to 0.04μ in diameter. A central nucleus, which stains deeply with certain dyes, is surrounded by a layer of protoplasm, sometimes radially striated, the whole being enclosed by a capsule. Reproduction, usually by division, has been described, the process commencing with the division of the nucleus. Ruffer and Walker have almost constantly been able to demonstrate the bodies in question in the large numbers of carcinomata which they have examined, and they appear to be present in greatest abundance at the spreading margin of the tumour. Although the parasitic nature of these bodies seems highly probable, it must be remembered that certain other conditions of epithelium cells may present appearances not altogether dissimilar. Thus Virchow long ago called attention to the fact that as the result of the division of a cancer cell one of the resulting cells may remain included within the other, a process called by him endogenous division. Again, very misleading appearances may be presented by the transverse section of an epithelium cell into which an adjacent cell has become partially invaginated, as well as by cells which have undergone colloid and other degenerations. The greatest caution is indeed necessary before deciding that bodies of various kinds included within cancer cells are really parasitic. Lastly, it must be remembered that even supposing the presence of true parasitic protozoa in cancer cells be definitively established, their causal relation to the disease cannot be proved until they have been successfully cultivated outside the body, and by inoculation have reproduced a carcinomatous growth. The important share which chronic irritation so often takes in the development of carcinoma in a cutaneous or mucous surface suggests that, even if cancer be a micro-parasitic disease, the specific virus will fail to act unless the part to which it is applied be prepared for it by a course of long-continued irritation.

The Geographical Distribution of Cancer is a most important element in the problem of its origin, and by a closer study of it than has hitherto been made, I believe that much light may be thrown on this.

Cancer appears to be a disease favoured by the aggregation of individuals under the influence of an advanced civilization; it seems to be much more common in civilized countries than amongst savage tribes.

The dwellers in large towns also seem more prone to cancer than those who live in thinly populated districts.

Cancer is rare in the frigid zone. The Esquimaux in the Western, and the Samoieds and other migratory tribes in the Eastern hemisphere, are to a large extent exempt from it. It is rare in the tropics generally, but McLeod, of Calcutta, informs me that it is far from uncommon in India. Cancer is certainly more common in Europe than in any other part of the civilized world. In some parts of the United States of America and in China also it appears to be of frequent occurrence, whilst in South America, in Africa (except Egypt), and in the greater part of Asia, it is not common.

Haviland, who has investigated the tables of mortality of this country with regard to the distribution of cancer in Great Britain, concludes that geological formation, soil, and resulting endemic conditions exercise a marked influence on the development of the disease. He finds, with regard to England, that cancer is most common in the western and north-western parts of the kingdom, including Wales; and that generally throughout the more elevated midland and southern districts it is not common. It is less frequent on the

older geological formations, towards the sources of rivers, and in dry well-drained districts. He points out, on the other hand, that the sites of the great cancer fields of England are the tertiary formations and the alluvial districts; that cancer surrounds the course of the great rivers after their full formation, when they are passing through valleys and low-lying lands liable to floods and to the consequent accumulation of alluvial deposits. These districts are also the most densely populated. Hence it may be inferred that density of population favours the production of cancer, and that wherever social organization is highly developed, there cancer becomes proportionately rife. But this view is not quite borne out by statistics. Thus we find that the development of cancer does not depend on mere population, as the mortality from cancer in Norwich and Great Yarmouth, comparatively small towns, is to that in such great centres of population as Liverpool and Manchester as 141 to 84, or nearly double; that in Philadelphia it is to that in the much larger city of New York as 15 to 7, or more than double; while in Marylebone it is very far higher than in the capital of Pennsylvania. In these conclusions we must not, however, omit to take into account the increased tendency to hereditary transmission amongst a comparatively settled population, such as that of the east of England.

It is interesting to note that not only are certain areas especially favourable to the development of cancer, but that evidence is not wanting to show that the same may be true even of individual houses. Law Webb has related how in a small village in Shropshire are "two houses under one roof, with a drain system and water supply common to both." In one house a man died of cancer of the rectum, and a married couple who next occupied the house died, the man of cancer of the stomach and his wife of cancer of the breast. Meanwhile a woman had died in the other house of cancer of the breast. Subsequently the first house was occupied by three maiden ladies, one of whom died of cancer of the uterus and another of cancer of the breast.

Is Cancer a Disease of Constitutional or of Local Origin? This question has led to much discussion among pathologists, and there are at least three theories with regard to it:—*a.* Cancer is a blood-disease. *b.* It is purely local in its origin. *c.* If local in its origin, it can be developed only in a constitution that is fitted in some way for its formation.

We will consider these views separately; and in so doing I may observe that it will be extremely difficult, if not impossible, to separate the two questions as to the origin and development of cancer from one another; for, however essentially distinct and separate they may be, they blend in such a discussion as this in an almost inextricable manner.

a. The doctrine that cancer is a blood-disease has been made to include two distinct propositions: the first that the blood itself is charged with the poison of cancer which is ready to burst forth in any part of the body on the application of the necessary local irritation; the second, that "blood-disease" and "constitutional disease" are synonymous terms. This latter is undoubtedly an error. It is quite possible to hold the view that the tissues are imbued with a cancerous tendency, without having recourse to the hypothesis that they derive this from the blood. The germinal membrane of the chick, as was pointed out by Gull, takes on changes antecedently to the formation of the blood; and so we may take it as possible that the tissues of the body may inherently possess morbid proclivities, independently of the blood by which

they are nourished. But if by blood-disease be meant a disease in which the blood actually contains the elements of cancer, as in gout it contains uric acid circulating through the body and capable of deposit in some favourable locality, this hypothesis is certainly untenable. There is no evidence either chemical or microscopic to support such a theory, and every phenomenon that occurs in connexion with cancer may be explained without it. But though the doctrine of cancer being a blood-disease is untenable in this sense, the same cannot be said of the theory that it is a constitutional affection.

The doctrine of the constitutional origin of cancer cannot be more clearly expressed than in the words of Paget:—"Cancers are manifestations of certain specific and morbid states of the blood; and in them are incorporated peculiar morbid materials which accumulate in the blood, and which their growth may tend to increase." "The existence of the morbid material in the blood, whether in the rudimental or in the effective state, constitutes the general predisposition to cancer; it is that which is by some called the predisposing cause of cancer. The morbid material is the essential constituent of the cancerous diathesis or constitution; and when its existence produces some manifest impairment of the general health, independently of the cancerous growth, it makes the primary cancerous cachexia." For the local manifestation of this constitutional disease, the part where it is developed must be put into a favourable condition by irritation, injury, or other similar cause. The blood-disease and the local conditions may compensate each other; thus, with an intense cancerous diathesis, tumours may be formed in such a way and in such numbers as to be apparently independent of local conditions; while in cases where the constitutional element exists in a low degree, a long continuance of irritation may be required to bring out its local manifestations. Paget believes that by this theory of compensation the opposing views as to the local or constitutional origin of cancer may be reconciled.

b. The theory that cancer is of local origin appears to be more generally adopted. The arguments on which it is based may be summed up as follows, and they are certainly sufficient to account for all the phenomena of cancer; and many of these phenomena do not admit of explanation on any other theory.

1. Cancerous tumours spring up in individuals who have always enjoyed perfect health, and who are to all appearance perfectly well at the time of the occurrence of the disease. As in these cases there is no evidence whatever of constitutional affection of any kind, it would be a begging of the whole question to assert that the existence of the local tumour must of itself be taken as an indication of a constitutional cancerous tendency.

2. Such primary tumours are almost invariably single. Primary cancer very rarely occurs at the same time at different seats of election—as the mamma, pylorus, and rectum, as would be the case were it constitutional.

3. Cancers are not unfrequently the result of some local injury or irritation. This is a matter of daily observation in the lip, the tongue, the female breast, &c.

4. The general health does not suffer until the glands have become implicated, or ulceration has taken place, when signs of cachexy may set in. In many cases of cancer, especially of the mamma, the health continues excellent for many months—a year or two even after the disease has declared itself, and so long as it continues to be confined to its primary seat. It is not

until after secondary deposits have occurred that the characteristic cachexy sets in.

5. If the primary tumour be removed before neighbouring parts have become contaminated, the health, if it have suffered, often improves materially.

6. All pathological evidence tends to show that the secondary growths arise directly as a consequence of the primary tumour, first, by extension by continuity of tissue; secondly, by extension along the line of the lymphatics; and thirdly, through the blood-stream, leading to growths scattered throughout the body in the same directions as the secondary abscesses in pyæmia which result from septic emboli.

7. Secondary cancers affect the form of the primary one. Thus, primary glandular cancer leads to deposit of masses of the same structure in the lungs; columnar carcinoma of the rectum to secondary growths in the liver, with identical structural peculiarities. The secondary growths scarcely ever appear in those parts in which primary growths arise; indeed they usually occur in tissues in which primary carcinoma is unknown, as the lymphatic glands and bones.

8. Growth is favoured by local circumstances, as the warmth and moisture of cavities.

9. In some rare instances no recurrence whatever takes place after operation, the disease being eradicated from the system, which could not be the case if it were constitutional.

10. When recurrence does take place soon after an operation, it is almost invariably either in the cicatrix or its immediate neighbourhood, or in the nearest lymphatic glands, owing to cancer cells which had been widely disseminated, escaping removal, and subsequently developing into new tumours. Were the disease constitutional, recurrence would be as likely to take place in other parts, especially in symmetrical parts.

The theory of the local origin of cancer is undoubtedly a very captivating one. It explains in the readiest and the simplest way possible most of the phenomena of the disease: but some pathologists doubt if it is competent to give a satisfactory solution of all.

There are at least four conditions that have been supposed to militate against the theory of the primary localization of cancer, and which have been adduced as evidence of the constitutional origin of the disease.

These are—1. The almost absolute certainty of the recurrence of the disease after the removal of the primary growth;

2. The frequent hereditariness of the disease;

3. The varying degrees of rapidity with which cancers run their course and the different degrees of virulence they exhibit in different individuals; and

4. The geographical distribution of cancer.

Let us briefly examine those conditions which have mainly been relied on in support of its constitutional origin.

1. The *liability to recurrence after removal* can have but little weight, when we consider the rapid tendency to diffusion which characterizes cancers, owing to their peculiar mode of growth, and the relation of the cells to the lymphatics. The fact is, that the cancer cells have already become diffused through the neighbouring structures, and may have entered the lymphatics or the blood long before the primary tumour has attained such a size as to attract attention.

One main source of error in respect to the origin of cancer has been, that it has usually been studied in organs, such as the mamma, in which the tumour often attains the size of a nut, or even a larger size, before it is detected; many months may have been required for the small group of cells from which the disease started to reach such a size, and during this time the surrounding tissues and lymphatics may have been widely infected.

2. The *hereditariness* of cancer is undoubted; but it is a fatal error in etiology to confound hereditariness with constitutionalism. Hereditariness may be local as well as constitutional. The hereditary transmission of a particular feature cannot be considered a proof of a constitutional tendency. So also the hereditary transmission of a malformation, as of supernumerary fingers or exostoses, is certainly purely local. But diseases may also be transmitted through descent without being in any way constitutional. Tumours that are not cancers are hereditary, as warts, lipomata, enchondromata, &c.; sebaceous cysts of the scalp are strongly hereditary, and yet there can be no pretence that these are in any way constitutional or blood-diseases. These are instances of hereditary local diseases that are not congenital, but develop after the body has reached maturity; just, indeed, as a cancer does. All that we can therefore assume is, that it is probable that in some cases there is a predisposition of unknown nature, hereditarily transmissible, which may favour the development of cancer; and that this hereditary tendency may be local, as in a certain tissue, or in a particular organ which is the usual seat of election of cancer, as the mamma, the testis, or the pylorus.

3. The *greater virulence* exhibited by cancers in some individuals than in others, and the *varying degrees of rapidity* with which they run their course, would undoubtedly lead to one of two inferences: either that the primary cancer is more active, has greater inherent vitality, or that the constitution in which it occurs is more favourable to its development.

The varying virulence of a cancer depends much more upon its anatomical structure than on any constitutional condition of the patient. All the glandular cancers are more malignant than the squamous or columnar; yet those who hold the theory that cancer is a blood-disease, maintain that it is a mere accident where the primary tumour arises, and consequently what form it assumes.

The locality in which the cancer develops has also much to do with the rapidity with which the glands are affected. H. Arnott pointed out that the softer, the more vascular, and the more movable the primary seat of the tumour is, the more rapidly the secondary growths appear. Thus carcinoma of the tongue always affects the glands very early, while with a similar growth on the skin of the leg the patient may escape glandular affection for many months.

The fearful rapidity of growth and virulence shown by a cancer of the mamma during pregnancy consequent upon the physiological increase of the supply of blood to the gland is another example of a local condition affecting the malignancy of the growth. Moreover, if great rapidity of the growth were due to the presence of the poison in the blood in greater amount than usual, we should expect to find the development of the tumour most rapid in those who showed the most marked cachexia, whereas the reverse is often the case. The younger the patient and the better the general health at the time of invasion, the more malignant as a rule will be the course of the disease.

Still it is highly probable that there is a tendency in the tissues of certain individuals to favour the development of these cancerous growths, originating primarily in some local irritation, whether this be traumatic or functional. Such a constitutional state, whether hereditary or acquired, is necessary to constitute a fitting soil for the cancerous element, in which to form and to develop. The stronger the tendency the more readily will cancer grow in such individuals, and the more rapid and vigorous will be the growth. This constitutional state does not develop a local cancer; it simply favours its development.

4. The *geographical distribution* has been already considered at p. 1057. It cannot be said that this has much bearing upon the question. The influences resulting from race, soil, climate, &c., are concerned in the development of many local diseases, such as simple bronchocele, elephantiasis of the scrotum, fibroma in the ears of negroes and the like, none of which are supposed to be due to the presence of a morbid material in the blood. We have no definite knowledge to guide us to any conclusion with regard to the effect of these influences on the development of cancer; and, in its absence, it is just as easy to suppose that these causes act locally on certain glands or epithelial surfaces as to imagine that they give rise to the development of some unknown poison in the blood to which the origin of the cancerous tumour is due.

Having thus described the cancer in general, we are in a position to consider more in detail the special varieties.

1. Glandular Carcinoma, the cells of which belong to the type of glandular or spheroidal epithelium, may arise in any parts in which glandular epithelium is normally present, such as the breast, salivary glands, liver, pancreas, prostate, kidney, and many other parts. Two chief varieties are met with:—1. Scirrhus or hard cancer, in which the stroma is very abundant and firm. 2. Encephaloid or soft cancer, in which the stroma is scanty and the cells abundant. No sharp distinction can be drawn between these two forms: a tumour which one Surgeon would call a rapidly growing scirrhus of the breast, another might describe as an encephaloid. A third variety of glandular cancer arises from colloid degeneration of the cells of either scirrhus or encephaloid, and this is known as colloid cancer, which will be described separately.

The glandular cancers yield on scraping or pressure a milky fluid, termed the *Cancer juice*, in which cells and granules are found in varying proportions. The granules are mostly fatty, and are the result of fatty degeneration of the cells of the tumour. This milky juice, it must be observed, is not absolutely characteristic of cancer. It is yielded by the lymphadenomata and by all the sarcomata, provided that at least twenty-four hours elapse after their removal before they are examined and that decomposition has commenced. The *Cells* (Fig. 388) are extremely variable in shape and size. They may be round, caudate, and even fusiform. Many varieties of form are usually found in the same tumour, but occasionally great uniformity prevails. The size may vary from $\frac{1}{2500}$ inch to $\frac{1}{800}$ inch. The nuclei are oval and highly refracting, often placed eccentrically; they are of considerable size and frequently double, while in some cases five or six may be found in the same cell. They contain bright shining nucleoli. The size of the cells is not indicative of the variety of the cancer. Thus, in some scirrhous tumours the cell may be small, and in others large, and the same may be said of encephaloid. The distinction between

scirrhus and encephaloid is made not by the size of the cells, but by the relative proportions of cells and stroma. All cancer cells are prone to early degeneration, usually becoming filled with fat granules, and ultimately breaking down and in great part disappearing, so that what was once a considerable mass of cells may be represented by a few granules. This is most marked in scirrhus.

The *stroma* in glandular cancers is almost invariably fibrous, but in the softer forms it may be composed partly of spindle cells. The alveolar arrangement is always clearly marked. The cells lie loosely in the spaces, often separated from each other by a small quantity of fluid. This fluid, with the cells, forms the "cancer juice." In the degenerating parts of the growth the stroma frequently contains numerous fat granules, and in very rare cases patches of calcification are met with. The *blood-vessels* are usually abundant, especially in the softer forms. In some rare instances they show curious bud-like processes and dilatations projecting from their walls into the alveolar spaces of the tumour. These may give way and distend the alveoli with blood, thus forming small rounded clots dotted through the growth. The unaided eye of the experienced Surgeon may in many cases recognize a cancer without difficulty, but in every case the tumour should be examined microscopically in order to determine without a doubt what its true nature is.

Fig. 388.
A. Cells from a large Encephaloid of the Breast.
B. Cells from Scirrhus of the Breast.
a. Stained. *b.* Unstained.
(454 diam.)

Hard Glandular Carcinoma. Scirrhus.—This is met with more commonly in the female breast than in all other parts of the body put together, and the cases that come under the care of the Surgeons are almost exclusively in that situation. Thus of cases of scirrhus admitted into the surgical wards of University College Hospital during the ten years 1871 to 1880, 113 were situated in the female breast, 1 in the male breast, 4 in the skin near the female breast, 1 in the kidney, and 3 in the prostate. Nine other cases were admitted as "scirrhus of the rectum," and two as "scirrhus of the sigmoid flexure," but these were not submitted to microscopical examination, and were most probably columnar carcinomata. Scirrhus is also met with in the stomach and pancreas, and a soft form—between the hard and soft cancer, and consequently sometimes called scirrho-encephaloid—is the ordinary primary cancer of the liver. Secondary scirrhus may occur in almost any part of the body, but the most common situations are the lymphatic glands, liver, lungs, kidneys, and bones.

Scirrhus occurs in two forms, the circumscribed and infiltrating. In either case it forms a hard, craggy, incompressible, and nodulated tumour, at first movable and unconnected with the skin, but soon acquiring deep-seated attachments and implicating the integument. It grows slowly, seldom attain-

ing a larger size than an orange. At times it is painless, at others painful, generally aching, sometimes with much radiating and shooting pain through it. These sensations vary according to the part affected, and to the sensibility of the individual: the pains are especially severe after the tumour has been handled, and at night are of a lancinating, neuralgic character. The tumour may thus continue in a chronic state for a considerable length of time, slowly increasing, gradually extending its deeper prolongations, and implicating the more superficial parts. In some cases, more particularly in elderly people, scirrhus gives rise to atrophy of the organ in which it is seated, causing wrinkling and puckering of the surrounding skin, which becomes adherent to the tumour; and the cancer may thus continue in a very chronic state.

The ulceration takes place usually by the skin becoming adherent at one point to the tumour, either by dimpling in, being as it were drawn down towards it, or else by being pushed forwards, stretched, and implicated in one of its more prominent masses; it then becomes dusky and livid red, somewhat glazed, and covered by a fine vascular net-work. Softening occurs at one point, where a crack or fissure forms; a clear drop of gummy fluid exudes from this, and dries in a small scab upon the surface; this is followed by a somewhat bloody discharge of a thick and glutinous character; and the small patch of skin from which it issues, becoming undermined, speedily sloughs away, leaving a circular ulcer. This gradually enlarges, becoming ragged and sloughy, with craggy everted edges, having irregular masses arising from its surface, and discharging a fœtid sanious pus. The pain increases greatly; and, the lymphatic glands becoming involved, cachexy is fully developed, and the patient is destroyed by it or by the secondary visceral deposits. In old people, ulceration of scirrhous cancers often assumes an extremely chronic character, the growth in them not having the same vitality as in the young. The ulcer in these cases is flat, sloughy, of a greyish-green colour, hard and rugged, with puckered edges, and much wrinkling of the surrounding skin, and exhaling the usual fœtid odour. In younger persons, and especially in stout women with florid complexions, the disease usually makes rapid progress. So also, if inflammation be accidentally set up in the neighbouring tissues, cancerous infiltration rapidly takes place in them. Occasionally, but very rarely, scirrhous masses slough out, leaving a large ragged cavity, which may even cicatrize; and thus a spontaneous cure has been said to occur, but this is doubtful. The cancerous infiltration extends to a considerable distance around the tumour into integument which to the naked eye appears quite healthy. In such tissue, however, the microscope may reveal unequivocal evidence of the existence of cancer cells diffused through it. Wherever the small-celled infiltration can be recognized, which surrounds a cancerous growth like a halo, and gradually shades off in the surrounding healthy textures, the tissues must be regarded as infected. It is of great importance in determining the question of operation to bear this in mind, and not to act on the supposition of the tumour being abruptly defined.

The secondary growths in scirrhous cancer form first in the lymphatic glands in almost every case; later on they may occur in the liver, lungs, bones, and other parts. In the lungs and liver they are frequently much softer than the primary growth, so that in some cases they might more properly be termed

encephaloid than scirrhous. In the lymphatic glands they are often almost as firm as the original tumour.

Structure.—On cutting into a scirrhus with the scalpel, it usually creaks somewhat as it is divided, and presents a whitish or bluish-white glistening surface, intersected by white bands, which apparently consist partly of new

Fig. 389.—Scirrhus of Breast (188 diam.). The communication of the alveolar spaces between one another, and the continuity of the contained masses of cells are well shown.

structure, and partly of included areolar tissue. This section has not inaptly been compared to the appearance presented by a cut through a turnip or an unripe pear.

A curious feature of hard cancer, in which it differs from almost all other tumours, is that it becomes cup-shaped on section. This seems to be due to

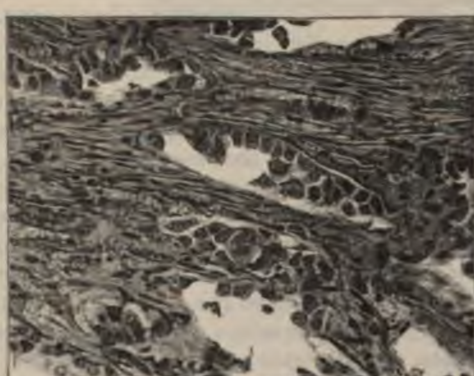


Fig. 390.—Scirrhus of Breast (188 diam.). In the alveolus which occupies the centre of the figure the accurate apposition of the cancer cells without any intervening stroma is clearly seen.

the fact that a kind of cicatrization often takes place in the central parts, while the peripheral parts are still growing. The cells undergo fatty degeneration and break up. The greater part of the products of degeneration are absorbed, and only a narrow streak of granules may be left to represent a once

large accumulation of cells. It is this shrinking of the growth that drags in the nipple in scirrhus of the breast. On examining a scirrhous cancer microscopically, it will be found to be surrounded everywhere by a zone of small round cells infiltrating the surrounding parts, penetrating between fat cells or muscular fibres, and extending along bands of connective tissue. A little nearer the centre the alveolar arrangement becomes apparent, and groups of rounded or irregular cells, with large oval nuclei, are found imbedded in spaces in a stroma of coarse fibrous tissue (Fig. 389). These spaces communicate with each other like those of a sponge. The stroma and cells here usually form about equal parts of the growth. The stroma shows signs of active growth, having spindle cells scattered here and there through it, sometimes in abundance. A little nearer the centre we find that the stroma has become more dense, the spindle cells being replaced by elongated tailed cells, with scarcely any protoplasm around the nucleus (Fig. 391). The cells of the cancer are here beginning to degenerate, the nuclei becoming hidden by clouds of fat granules, and a similar change may also be apparent in the stroma. Towards the centre the fatty cells disappear, and only a few granules mark where they were; the stroma becomes dense and hard, and even the nuclei before mentioned are difficult to recognize. The above is a description of the ordinary scirrhus of moderately slow growth. In more vigorously growing specimens the degeneration is delayed, the cicatrization is less perfect, and the relative proportion of the cells is greater.

Fig. 391.—Scirrhus of Breast (188 diam.). Much cicatrized; the stroma bears a large proportion to the cells, which are small and granular. In a fully cicatrized specimen there would be similar alveolar spaces containing only granular *débris*.

It is not always easy to determine the exact mode of growth in scirrhous cancer, as the young spheroidal epithelium cells closely resemble the small round cells infiltrating the tissues at the growing margin. In the softer and more diffused forms, however, it is often possible to observe the earliest changes in the acini. It will then be seen that the morbid process does not start from a single acinus. Many acini lying near each other may show various stages of overgrowth of the epithelium. As first the new cells are contained within the distended membrana propria of the acinus, but as the process advances, they burst beyond its limits, and penetrate among the surrounding tissues. In the harder tumours of slower growth this often cannot be recognized, as the area of the gland affected is smaller, and by the time it comes under observation the acini have disappeared, and columns of cells only are found extending into the surrounding tissues.

Soft Glandular Carcinoma. Encephaloid.—As before stated, this is not separable from scirrhus. The greater part of the tumours which were formerly classed as encephaloid cancers are now included under the sarcomata. A glandular cancer growing with such rapidity, and of such softness

of structure, as to merit the name of encephaloid is in fact of rare occurrence in surgical practice. During the ten years 1871 to 1880, there were admitted under the care of the Surgeons of University College Hospital only eight cases which were classed as encephaloid cancer. Five of these were in the breast, two in the testicle, and one was believed to have originated in the tonsil or the glands in its neighbourhood. Encephaloid cancer, like scirrhus, arises only in structures containing glandular or spheroidal epithelium. It commences as a tumour, which though occasionally somewhat hard, is usually from the first, or at all events soon becomes, soft and elastic, being more or less lobulated, growing rapidly, and having an elastic and at last a semi-fluctuating feel. The skin covering it is usually at first pale and loose, with a large net-work of dilated veins spreading over it. In some cases, however, at a very early period, a species of inflammatory œdema occurs in the integuments covering a rapidly growing encephaloid tumour. As the tumour

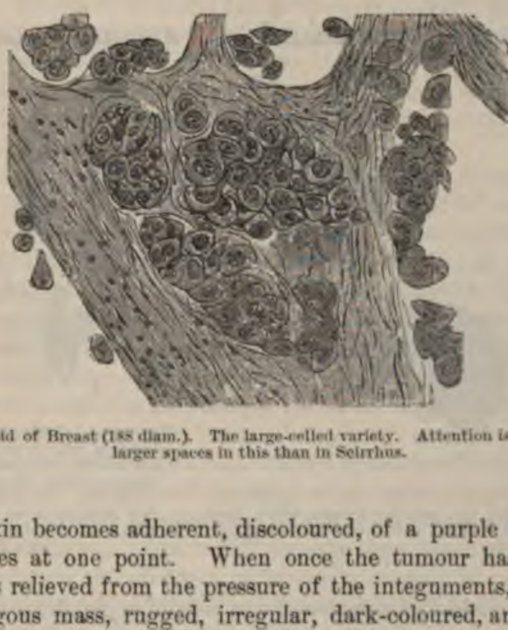


Fig. 392.—Encephaloid of Breast (188 diam.). The large-celled variety. Attention is directed to the much larger spaces in this than in Scirrhus.

enlarges, the skin becomes adherent, discoloured, of a purple brown tint, and at last ulcerates at one point. When once the tumour has made its way through, and is relieved from the pressure of the integuments, it may form a large soft fungous mass, rugged, irregular, dark-coloured, and bleeding profusely. This resembles the same condition occurring in some rapidly growing soft sarcomata to which the term *fungus hæmatodes* was applied by Hey. In other cases the tumour may slough, forming a deep irregular cavity. In either case death rapidly ensues from exhaustion and hæmorrhage. Pulsation from extreme vascularity, accompanied by a loud bruit, to be heard on auscultation, has been described as occurring in encephaloid cancer, but in most cases in which this symptom has been recorded, the tumour was probably not a cancer, but a soft sarcoma, as these morbid growths were formerly confounded together.

The constitutional cachexy in encephaloid occurs early and is well marked, and secondary growths speedily make their appearance in the lymphatic glands and viscera.

Structure.—After removal the tumour is found to be very vascular, dis-

playing on injection a close net-work of vessels. On a section being made, it commonly presents a soft pulpy white mass, closely resembling cerebral substance, stained and blotched with bloody patches, varying in colour from a bright red to a maroon-brown, this being dependent on blood that has been infiltrated into its substance. In other cases, its section has been compared to that of a raw potato, or a piece of boiled udder. On microscopic examination, it will be found to present a structure essentially similar to that of scirrhus, that is to say, an alveolar stroma enclosing groups of free cells of an epithelial type. The cells may in some cases be larger, but are often smaller than those usually seen in scirrhus (Fig. 392). They assume the same irregular forms, and have each one or more highly refracting nuclei and nucleoli. The proportion of the bulk of the tumour composed of cells is, however, infinitely greater in encephaloid than in scirrhus, and the vascularity of the tumour is proportionately increased. The tumour does not show the same tendency to cicatricial contraction, although fatty degeneration always occurs in the central parts.

Colloid, Gelatinous, Gelatiniform or Alveolar Cancer is a variety

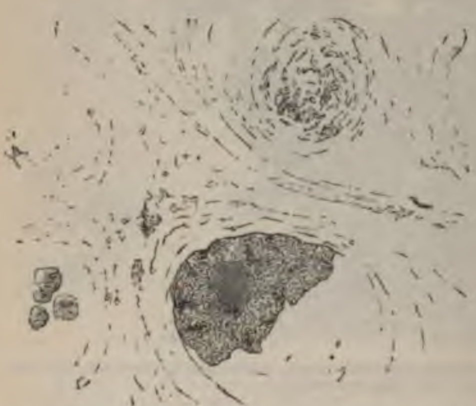


Fig. 393.– Colloid of Omentum (188 diam.) Shows the concentric rings and the granular masses which have taken the place of the cells; and at one part a few cells still retain their shape.

Fig. 394.—A. Colloid of Breast. Shows relation of cells to stroma, and the colloid material in some cases filling the cell, in others pushing the nucleus to one side or completely surrounding it. B. Isolated cells from the same tumour. C. Isolated cells from colloid of omentum. (454 diam.)

formed by the colloid degeneration of the cells of a glandular cancer, either of the scirrhous or encephaloid form, but most commonly the former. It may occur in distinct masses, often of a very large size, weighing many pounds, or may be infiltrated into the tissue of organs. As it is most frequently met with in the viscera of the abdomen, it does not so often fall under the observation of the Surgeon as the other varieties of cancer. Yet it is not uncommon in the breast, where I have met with it, forming a very large tumour. Colloid cancer consists of alveolar spaces visible to the naked eye, filled with a clear semi-transparent yellowish gelatinous or honey-like material, resembling indeed somewhat the structure of a honey-comb. The septa forming these spaces are distinctly fibrous and regular in their arrangement (Fig. 393). Some of the spaces are completely filled with colloid matter, others may show a few cells containing fat granules in the centre, surrounded by zones of granules resulting from the degeneration of other cells. Cells again may be seen in the pro-

cess of undergoing colloid degeneration (Fig. 394). A globule of colloid matter first appears pushing the nucleus to one side; afterwards the nucleus undergoes a similar degeneration; and finally the cell bursts and disappears, leaving behind it only a few granules. True colloid cancer is merely a degeneration of scirrhus or encephaloid. Many other tumours have been described in former times as colloid, amongst which may be mentioned many myxomata, œdematous soft fibromata, and some glandular tumours which had undergone colloid degeneration.

Diagnosis of Glandular Carcinoma.—In the diagnosis of a cancer the age of the patient is an important consideration, such tumours being very rare before 30. Too much importance must not be attached to an hereditary history of cancer, or it may lead us into error. A most important sign of cancer is that the tumour forms part of the structure it is invading. It may be tolerably clearly defined in outline, but it is not separable from the surrounding tissue. It early becomes adherent to the skin when occurring in a superficial part. In the later stages the adhesion is evident, but at first it can be recognized only by pinching up the skin widely with the finger and thumb when it will be seen to dimple slightly at the part over the tumour. Both these signs, the implication of the surrounding structures and the dimpling of the skin may, however, also be present in chronic inflammation with fibroid induration.

The diagnosis of the different forms of cancer is not always easily made. *Scirrhus*, when not widely infiltrating, may very readily be confounded with fibrous tumours and adenomata, or with chronic inflammatory induration of a part; in many of these cases, indeed, the diagnosis cannot be made correctly until after examination by incision. In other cases, however, the rugged feel, the lancinating pains, the implication of the lymphatic glands, or the affection of the general health, will commonly serve to establish the diagnosis. When ulceration has taken place, the previous condition of the tumour, the general character of the sore, and the microscopic examination of the *débris*, may serve to denote its true character.

Encephaloid may be confounded with abscess, cysts, erectile and sanguineous tumours, and with the various soft varieties of sarcoma. In these cases careful palpation, the existence of elasticity without fluctuation, and the presence of the large and tortuous veins ramifying over the surface of the mass, may establish its true character. When it is fungating, it may be confounded with the sprouting intracystic growths that sometimes spring from the interior of a cystic tumour or with a soft sarcoma. Here, however, the history of the case and the contamination of neighbouring lymphatics, will show the true nature of the affection.

In all cases in which there is doubt as to the nature of the growth an incision should be made into it, if it is a case fit for removal by operation, and, if necessary, a slice should be removed and examined with the naked eye, or a scraping of it, or a section cut after freezing, may be put under the microscope. It is much better to do this than to lose valuable time by waiting till the symptoms become more definite.

2. Squamous Carcinoma, or Squamous Epithelioma.—Squamous epithelioma, or as it has been called "epithelioma," "epithelial cancer," or "cancroid," was at one time considered to be distinct from true "cancer." There is nothing, however, to justify such a distinction. The term epithelial cancer or "epithe-

lioma" is not a good one, for as has just been pointed out, the scirrhus and encephaloid are equally epithelial growths though arising from a different type of epithelium. Squamous carcinoma arises from any situation in which squamous epithelium is naturally present. The essential feature of the growth by which it is distinguished from a simple wart or papilloma is that the epithelium no longer merely covers the papillæ, but forces its way between them into the structures beneath.

Causes and Situation.—Squamous carcinoma, rare in the young, is common in middle-aged or elderly people, the tendency to it increasing in proportion as age advances. In this respect it follows the course of other cancers. The hereditariness of epithelioma is not so marked as that of scirrhus, so much so that it has been doubted. I have no evidence either way on this point. My impression is that it is not distinctly hereditary. It has been said to have been communicated by contact from the uterus of the female to the penis of the male, but this is extremely doubtful. It is certain that in the great majority of cases in which such contact has taken place no evil consequences follow.

It is frequently occasioned by the long-continued or repeated application of some source of irritation, and may thus be established in constitutions otherwise perfectly healthy. Thus the irritation of a broken tooth upon the tongue or cheek may produce epithelioma of those parts. The scrotum in chimney-sweepers may be the seat of epithelioma, in consequence of the lodgment and irritation of soot in its rugæ. Cancer of the tongue or lip is frequently attributed to the irritation caused by smoking. In some cases epithelioma arises in parts which have long suffered from an abnormal condition of the epithelium. Thus the so-called "smooth or scaly tongue" has a great tendency to terminate in cancer, sometimes after the condition has lasted for ten or even twenty years. Epithelioma not unfrequently originates in old scars.

Its most common seat is on muco-cutaneous surfaces. During the ten years, 1871 to 1880, 123 cases of squamous epithelioma were admitted into the surgical wards of University College Hospital. They were distributed as follows: tongue, 52; lips, 18; skin of limbs and trunk, 10; penis, 8; vulva, 7; cheeks and gums, 7; anus, 4; scars in various parts, 3; skin of face, 3; scrotum, 2; œsophagus, 2; larynx, 2; bladder, 2; soft palate, 1; and antrum, 1. During a similar period 47 cases of cancer of the uterus were admitted into the women's ward, but the hospital report does not distinguish between the different forms of the disease in these cases. Eleven cases of malignant stricture of the œsophagus, probably all epithelioma, were also admitted into the medical wards.

The selection of a particular site by epithelioma appears often to be capricious, though it is doubtless dependent on anatomical peculiarities of the part. Thus it is common in the lower lip, but very rare in the upper. In women it rarely attacks the lip, in men often; when occurring in mucous canals it chiefly affects their ends. Thus the lower end of the pharynx, the upper end of the œsophagus, and the anus are all favourite sites.

Progress.—Squamous carcinoma commences either as a small flat tubercle, or a warty growth, which rapidly ulcerates. Sometimes when it first comes under observation, it may already form an intractable fissure, or ulcer, of limited size, with hard everted edges and a foul surface. In other cases,

papillæ of great size may form on the surface of the growth before ulceration takes place. This is especially marked in cancer of the penis, in which the papillæ are sometimes half an inch in length. In the bladder epithelioma may assume a villous form. When ulceration takes place the destruction of tissue slowly spreads, implicating every structure at its circumference. Such an ulcer attacks not only the soft parts, but may extend into a neighbouring bone, penetrating deeply into its structure and eroding it. In a case under my care, in which the ulceration started from a gland secondarily affected after removal of an epithelioma of the lip, the greater part of the symphysis of the jaw was destroyed and the whole floor of the mouth eaten away till the tongue hung out below on the skin of the neck. Epithelioma of the eyelids may invade and destroy the eyeball, and when arising from the mucous membrane of the nose it may form one variety of the so-called malignant polypus. I have seen an epithelioma as large as a small orange, developing in this situation and passing into the orbit and to the cheek. Epithelioma of the scrotum, if left unrelieved by treatment, will at last extend to and implicate the testicle.

After an epithelioma has lasted a certain time secondary growths appear in the nearest lymphatic glands. This takes place with varying rapidity in different cases. It was pointed out by Henry Arnott that the implication of the glands takes place most rapidly when the primary growth is situated in soft, vascular parts much exposed to movement. Thus it takes place much more readily in epithelioma of the tongue, than in the same disease of the skin of the trunk. The affected glands increase in size steadily, but not usually very rapidly, and after a time fresh glands become infected. When they reach the surface they adhere to the skin, the central parts soften and become diffluent, and finally the skin gives way and a ragged, foul cavity is exposed, discharging a thin, blood-stained fluid, which tends to become extremely offensive. Squamous carcinoma differs from glandular carcinoma in one important respect: it has but little tendency to extend beyond the lymphatic glands, and to appear in the viscera or distant parts. It does so, however, with sufficient frequency to show that the absence of secondary tumours in the viscera is not an essential feature of the tumour.

Fig. 395.—Squamous Carcinoma of Lower Lip. Male: about 21.

Epithelioma most commonly occurs in otherwise healthy subjects. Even after the glands have become affected the general health may be but little impaired for some time; but sooner or later the patient begins to lose flesh and the so-called "cancerous cachexia" makes its appearance. Epithelioma may prove fatal by the progress of the local disease, and by its external ulceration; by its affecting a part essential to life, as the œsophagus or larynx; by pressure of enlarged glands on important parts; and by the induction of constitutional cachexy and malnutrition with gradual exhaustion.

Structure.—On microscopic examination, a squamous carcinoma will be found to be composed of masses of cells of the type of scaly epithelium, form-

ing irregularly cylindrical processes communicating with each other. From the irregular course of these processes, they are cut in a variety of directions in every thin section, so that the groups of cells do not give the idea of cylinders, but rather of circular, oval, and irregular masses not in direct connexion with each other. Between these cylinders is a fibrous tissue bearing abundant vessels for the nutrition of the non-vascular epithelium. This fibrous tissue is more or less infiltrated with small round cells, in proportion to the rapidity of the growth of the tumour. It will be seen from the above description that the structure of a squamous carcinoma, although differing in detail, is in the main similar to that of glandular carcinoma: that is to say, cells of an epi-

Fig. 396.—Squamous Carcinoma of Anus (40 diam.). Shows the lobules extending down into the connective tissue, which is infiltrated with small round cells; four globes are seen. The isolated masses are probably cylinders cut obliquely.

thelial type, imbedded in spaces in a fibrous stroma, which freely communicate with each other (Fig. 396).

As in normal squamous epithelium covering a papilla of the skin, the cells next to the fibrous and vascular tissue are softer and rounder in form than those of greater age. In the centre of the terminal portion of a cylinder of cells or in a branching process from it, the epithelium often becomes flattened by pressure, and arranged circularly so as to form a globe (epithelial nest, epithelial pearl). These nest-like formations are produced, according to Virchow, by the remarkable tendency to endogenous cell-growth exhibited by some of the central cells, and the development of large "brood-spaces" within them. The pressure produced by this formation of brood-spaces, and the endogenous cell-growth accompanying it, cause the marginal cells to become flattened and to take on a concentric arrangement. Possibly these globes may be formed in both ways; but the appearance usually presented by them rather suggests the former than the latter process, as the central parts are most

frequently dry and hard, and show no signs of active growth. Similar globes are not unfrequently formed in simple warty growths, and must therefore not be considered diagnostic of epithelioma. The fully formed cells often present beautifully serrated edges, the serrations of one joining those of its neighbours. This is well shown in Fig. 397, taken from a small epithelioma of the anus which I removed from a middle-aged man. The individual cells of an epithelioma, as obtained by scraping, differ but little from the healthy scaly epithelium that may be got from the mucous membrane of the cheek or lip. They are often larger, and sometimes contain more than one nucleus. In the older parts of the growth, they are usually filled with fat granules. When an epithelioma has undergone ulceration, the surface is frequently covered with prominent masses like large granulations, and the diagnosis of the nature of the growth can often be made by removing one of them and submitting it to microscopic examination. If in a simple ulcer the skin be completely destroyed, epithelium is never found except at the margins; in an epitheliomatous ulcer, on the contrary, it is found at every part of the ulcerating surface. The *vessels* of epithelioma are abundant, but not so plentiful as those of scirrhus or encephaloid. As to the relation of the growths to the *lymphatics*, there is some difference of opinion. Thiersch and Waldeyer believe that they have demonstrated a lymphatic endothelium covering the cylinders of cells, and consequently are of opinion that the epithelium is actually within lymph-spaces. The anastomosis between the cancer cylinders is said exactly to resemble that normally seen between the lymph-spaces. The secondary tumours present the same general characteristics as the primary growth, but they are usually softer. The cells are sometimes thicker and less distinctly squamous, but most commonly their type is easily recognized. Epithelial nests are always less abundant and sometimes wanting.

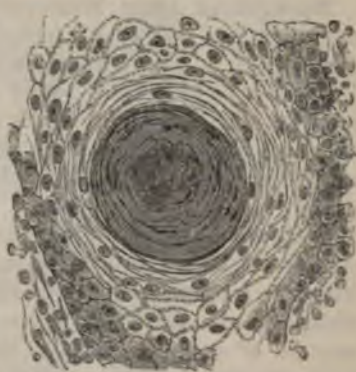


Fig. 397.—Squamous Carcinoma of Anus (188 diam.). Illustrates the structure of an epithelial globe, and shows the "prickle cells" which occur normally in the Malpighian layer of the skin.

The mode of growth of squamous carcinoma can often be observed without difficulty. If, for instance, a small warty epithelioma from the lip be removed in an early stage and examined microscopically, it will be found to be composed of hypertrophied papillæ covered with an exuberant growth of scaly epithelium. The papillæ increase in size as the centre of the growth is approached. The cutis vera beneath the large papillæ and the papillæ themselves are infiltrated with small round cells. In the circumferential parts of the growth the epithelium will be found to be entirely superficial, but in the central parts, between two or more papillæ, a process of epithelium cells will be seen forcing itself into the cutis vera, which is very abundantly infiltrated at that spot with small round cells. So long as the epithelium is all superficial, the growth cannot be said to be malignant, and would be classed as a simple wart: whenever the epithelium cells can be seen bursting through between the papillæ and extending into the tissues beneath, the growth is undoubtedly

cancerous. The scaly tongue undergoing conversion into epithelioma also offers a favourable opportunity of observing the same process.

Diagnosis.—The diagnosis of squamous carcinoma from the other forms of cancer is usually easy. The principal points that should guide the Surgeon are: 1. The invariable occurrence of growth on a mucous or cutaneous surface. 2. Its early ulceration—often almost from the very commencement. 3. The rapidity with which ulceration follows on the new growth. 4. The origin of the disease from some evident source of external irritation. 5. The absence of all evidence of contamination of internal organs.

The **Prognosis** of squamous carcinoma is more favourable than that of the glandular varieties. Its superficial origin makes it possible for the Surgeon to recognize it early and remove it before the glands are affected, and even after glandular enlargement has taken place there is hope of completely eradicating the disease by removing the affected glands.

Recurrence after Removal takes place in squamous as in glandular cancer in the scar or its immediate neighbourhood, and in the lymphatic glands, and in these situations is due to the same pathological conditions. Distant recurrence is, as before stated, less common, but when it does take place it is due, as in other forms, to dissemination of cancer elements throughout the body. In one case in which I removed an epithelioma of the tongue recurrence took place in one of the toes and in the lung after a lapse of nearly two years.

Epithelioma, however, presents the peculiarity of re-appearing in some rare cases in the neighbourhood of the primary growth and yet not in connection with it. In these cases it would appear as if there was a tendency to the disease in the particular region of the body. Thus I have seen after the removal of an epithelioma of the lip on one side, a similar growth appear inside the mouth on the other side. The interval between the appearance of the growth is usually longer than in genuine recurrence. Thus, in the case above mentioned, three or four years elapsed between the removal of the epithelioma on the left side of the lower lip and the appearance of that inside the right cheek.

It would appear as if epithelioma were sometimes capable of transplantation or of inoculation so as thus to be locally multiplied. I have seen an epithelioma of one labium apparently inoculate an abrasion on the opposite one where a fresh centre of disease developed, and an epithelioma of the tongue infect the lower jaw through the contiguous alveolus of a loose tooth.

3. Columnar Carcinoma or Columnar Epithelioma.—This form of tumour has frequently been called "adenoid cancer," but the term "columnar carcinoma" is less likely to lead to confusion and more correctly expresses the nature of the growth. It occurs as a rule at the same age and under much the same conditions as squamous carcinoma. It is confined to those regions which are naturally covered by columnar epithelium, and forms the most common tumour of the pylorus and intestine, including the rectum. During the ten years 1871 to 1880, there were admitted into the surgical wards of University College Hospital twenty-five cases of cancer of the rectum described as columnar epithelioma, and nine in which the form of cancer is not clearly stated, which were probably of the same variety. Four cases are recorded as having been met with in the sigmoid flexure and one in the antrum. It is

met with also in the uterus, ovary, and gall-bladder, and, in rare cases, in the breast, springing from the larger ducts.

Appearance and Progress.—A columnar carcinoma bears the same relation to the papilloma of the intestine that the squamous carcinoma does to the common wart on the skin. A simple papilloma as it increases in size keeps its superficial character, and becomes in most cases pedunculated and shows little tendency to ulcerate. A columnar carcinoma spreads widely with a somewhat firm fleshy base. Its surface remains papillary at the circumference, but soon ulcerates in the central parts, becoming rugged and irregular, and bleeding readily and abundantly. The growth extends through the whole thickness of the gut, and may implicate neighbouring viscera. Columnar carcinoma shows a much lower degree of malignancy than squamous carcinoma. It grows as a rule slowly, and frequently does not affect the lymphatic glands

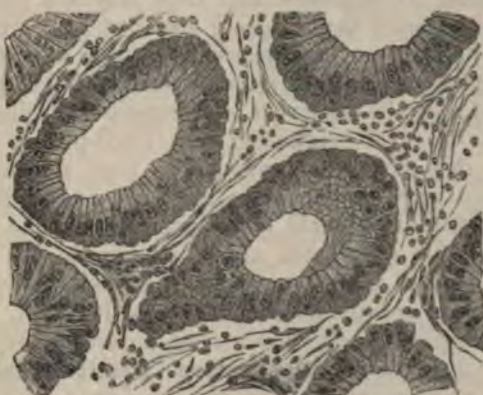


Fig. 398.—Columnar Carcinoma of Transverse Colon (188 diam.). One tube is cut obliquely, the others transversely; the epithelium is irregular in shape and size, and is sometimes arranged in more than one layer. The stroma is fibrous, containing small round cells.

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Death commonly takes place from the local disease, either from exhaustion from the discharge and loss of blood or from obstruction of the bowel or pylorus.

Structure.—A section of such a growth (Fig. 398) shows it to be composed of tubes lined with columnar epithelium, bound together by a delicate connective tissue, more or less infiltrated with small round cells. The tubes resemble gigantic crypts of Lieberkühn. By the microscope alone it is not always easy to distinguish these tumours from simple papillomata covered with columnar epithelium, in which the bases of the papillæ on section give the appearance of tubes. The irregularity of the structure and the greater cell-infiltration of the connective tissue would lead to a suspicion of malignancy. If the base be examined and the proper structure of the tumour be found implicating the muscular coat or extending to neighbouring parts, its malignant nature is placed beyond a doubt.

The secondary growths met with in the glands and liver maintain the characteristic features of the primary tumour, so that a tissue, looking like crypts of Lieberkühn irregularly massed together, may be found in the lym-

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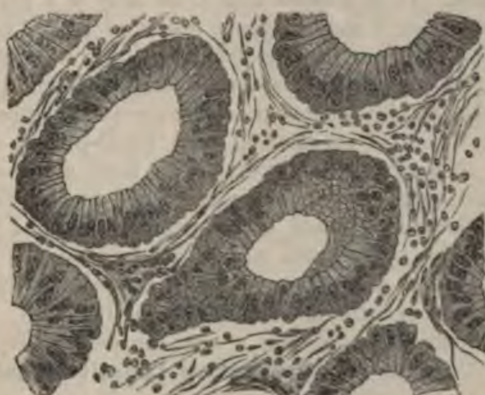

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phatic glands or in the liver. In the lymphatic glands of the groin these tumours may break down and ulcerate, as in squamous carcinoma.

Diagnosis.—The diagnosis of the nature of the growth can be made only when it is situated in the rectum. It is then often possible to remove a small portion for microscopic examination.

The **Prognosis** is always very grave on account of the situation in which the tumour forms. Limited growths may be safely removed from the rectum, and lately such tumours have been excised both from the colon and pylorus, the parts being united by suture of the intestine.

Other Forms of Cancer were formerly described, the chief of which were Osteoid Cancer and Melanotic Cancer. Osteoid Cancer was the name given to the tumour now known as Osteoid or Ossifying Sarcoma (see p. 1042). The growths formerly described as Melanotic Cancer are also now classed with the sarcomata. It is possible that there may be a pigmented form of squamous carcinoma, but if such a tumour does exist it must be of great rarity.

TREATMENT OF CANCER.—The treatment of cancer will necessarily be in a great measure dependent on the view that is taken of its origin. The constitutionalists would naturally endeavour to discover some method of preventing the development of or of eradicating that blood-poison, or that general tendency which they suppose to underlie the local affection. They would necessarily discard operation as being not only useless, but erroneous in principle—as erroneous as it would be to amputate the foot to cure the gout. The localists, on the other hand, necessarily rely on the removal of the primary local disease at as early a period as possible, as the only means of preventing secondary growths and constitutional infection. Hence the discussion as to the origin of cancer has a most important practical bearing on the treatment of the disease. All **Curative Constitutional Treatment** is certainly useless, no constitutional remedies appearing to exercise any material influence on the disease. I am not acquainted with any case of cancer, either from my own observations, from conversation with other Surgeons, or from published statements, that affords satisfactory evidence of cure by an internal remedy. It is true that many so-called cases of cancer have, at various times, been stated to have been cured by different medicines; but it must be borne in mind that, at one time, almost all hard chronic tumours were called "scirrhous," and many intractable ulcers "cancers;" mistakes which are sometimes unavoidably committed, even with the improved means of diagnosis that we at present possess. Not one of the many remedies that have been vaunted as being specific in this disease, and by which cures have been stated to have been effected, has obtained the confidence of the profession, or has, on further trial, corresponded in its effects to the statements of those who introduced it. I therefore think it but waste of time to discuss the supposed benefit to be derived from hemlock, sanguinaria, condurango, Chian turpentine, iron, arsenic, iodine, cod-liver oil, or lemon-juice, in the treatment of cancer. But though curative treatment can effect nothing, much may be done by proper *Palliative Treatment* towards retarding the progress of the cases that do not admit of operation. With this view, the diet should be mild, nutritious, easy of digestion, unstimulating, and sufficient to support the strength under the wearing influence of pain and discharge; and the preparations of opium, conium, and hyoscyamus, must be freely administered in order to relieve the patient's sufferings, and to procure rest.

The **Local Means** are those upon which the Surgeon justly places the chief reliance. The **Palliative Local Treatment** consists in the use of means calculated to retard the growth of the tumour, to lessen the pain attending it, and to remove the fœtor that arises if it be ulcerated. It is important to remember that the rapidity of the growth and the pain will usually be increased by anything that causes hyperæmia of the part. All irritating applications such as tincture of iodine must therefore be avoided; they only hasten the growth of the tumour and the implication of the skin. If the tumour be painful, and the skin covering it still unbroken, great relief may be obtained by the application of belladonna plasters. In some cases I have found powdered conium, spread on cotton-wadding, useful in the same way. As it is of importance to prevent, as long as possible, any breach of surface, the application of these sedative plasters and powders should be persevered in with the view of supporting the integument. The local application of ice was recommended by J. Arnott; but there is no evidence to show that it is of any real service. When the tumour is ulcerated, the fœtor must be diminished by the application of weak solutions of carbolic acid, chloride of zinc, chloralum, or permanganate of potash, to which cocaine or opiates may advantageously be added with a view of lessening the pain. Thymol and menthol both prevent decomposition and allay pain. Iodoform sprinkled over the ulcerating surface will often be found to diminish both the fœtor and the pain. If the smell of the iodoform is unpleasant to the patient, an ointment may be used composed of iodoform ʒj, eucalyptus oil ℥j, paraffin and vaseline ā ā ℥iiss. This may be applied on a piece of muslin and the parts covered with a sheet of salicylic wool. Von Mosetig-Moorhof has recorded cases of extensive malignant disease in which shrinkage of the growth has followed the local application of methyl-violet. A 1 in 500 solution was used and frequent injections of from 3 to 6 grammes of the solution made into the diseased tissues.

The **Curative Local Treatment** of cancer consists in a free removal of the tumour, together with such a margin of the surrounding tissues as is likely to be already in process of invasion.

Before proceeding however to consider the methods now usually employed for this purpose, it is necessary to say a few words regarding two methods which were formerly recommended, viz., the use of caustics, and compression.

The employment of *caustics* for the destruction of cancers has, in all ages and countries, been resorted to by empirics, who profess to remove tumours of a malignant nature, by secret remedies, less painful and more effectual than the knife. In this country they have never enjoyed any very extended reputation; and now that anæsthetics have removed the pain of an operation and antiseptic treatment has reduced its dangers to a minimum, it is very rarely that the Surgeon is justified in using them. Of the very numerous caustic substances which have been employed the following may be mentioned:—the concentrated mineral acids, especially the fuming nitric and anhydrous sulphuric acids; caustic alkalies, especially potash and lime, either alone or in combination in the form of Vienna paste; certain mineral salts, such as the chlorides of antimony and zinc, the acid nitrate of mercury, sulphate of zinc, and arsenious acid.

At the present day caustics are occasionally useful in the treatment of certain forms of carcinoma in which the complete removal of the growth by operation is impossible. Thus in some cases of cancer of the jaws in which

the disease is found to have extended too far to allow of its complete excision, caustics may with advantage be applied when the accessible part of the growth has been removed. For this purpose the most efficient material is a paste containing one part of chloride of zinc to four parts of flour, moistened with a little water, to which one-twentieth part of extract of opium may be added to diminish pain.

Again, in certain forms of fungating carcinoma of the cervix uteri temporary relief may be afforded by freely scraping the growth and then applying a strong solution of chloride of zinc.

Compression is a plan that was at one time greatly extolled and at another much depreciated, and may now be said to be of merely historical interest. It was fully tried at the Middlesex Hospital, by Young, more than sixty years ago, and unfavourably reported upon by Charles Bell at that time; it consequently fell into disuse in this country, but was revived by Récamier in France, and employed largely by him. Although he published a favourable account of this practice, it made but little progress amongst French surgeons; the only one who seems to have used it to any extent being Tanchou, who employed a peculiar topical medication conjoined with it. In this country the practice fell into complete oblivion, until J. Arnott invented a mode of employing pressure by means of an elastic air-cushion; after which time it was often employed, but with no real success as a means of cure.

I have employed all the different plans, but have never found permanent advantage from any of them.

That indurated masses in the mamma have disappeared under this treatment cannot be denied. Walshe records such a case in his *Treatise on Cancer*, but the well known difficulty of diagnosing a chronically inflamed lobule, which would probably be absorbed under pressure, from a small cancer, makes these few isolated cases of no value when we contrast them with the large number of failures in undoubtedly cancerous growths.

Excision.—With regard to the question of removing cancers by the knife, a difference of opinion necessarily exists between the constitutionalists and the localists, the former holding the view that however completely the primary disease be removed recurrence is almost inevitable, and the latter, that if the Surgeon can only get the case early enough and remove the diseased parts sufficiently widely a cure may be effected. That recurrence after removal is the rule cannot be denied. Astley Cooper stated that in only nine or ten cases out of a hundred did the disease not return in three years; Benjamin Brodie found that it generally proved fatal in two or three years after the operation, and Paget has expressed the same opinion. Since anæsthetics have made it possible to spend a longer time over the operation, and antiseptic treatment has removed the fear of large wounds, many Surgeons have advocated a more free removal of the affected parts than was formerly practicable. Thus Küster, Kocher, and Mitchell Banks have advised that whenever it is practicable the nearest lymphatic glands should be removed with the primary growth. Operating in this way on mammary cancers with very free removal of the skin and extirpation of the axillary glands, Mitchell Banks has obtained excellent results. Out of forty-six cases operated on by him, ten patients were alive and free from recurrence at different periods, varying from two to ten years, after the operation, and in five more no recurrence had taken place from one to two years after

the operation. Küster states that in 26 per cent. of his cases no recurrence had taken place three years after the removal of the breast.

In determining as to the advisability of operating in cases of cancer, several questions of great importance present themselves to the consideration of the Surgeon. He has first to consider whether the operation is likely to rid his patient completely of the disease; or, in the event of its not doing so, whether life may not be prolonged by the removal of the cancerous tumour; or, lastly, whether the patient's sufferings may not be much lessened by the removal of the local affection, although there be no prospect of really prolonging life.

The two following questions will therefore present themselves to the Surgeon in considering this subject :—

1. Can cancer be cured, or, rather, completely extirpated from the system by excision?

That in some cases a cancerous tumour may be removed with every expectation of the patient being completely freed from the disease, cannot, I think, be doubted. Velpeau stated that he had perfectly cured patients by the removal of cancerous tumours—at least, that no return had taken place for 12, 15, or 20 years after extirpation. The evidence of Brodie on this point is extremely valuable. Writing in 1846, that eminent Surgeon says: "So long ago as 1832, I removed a breast affected with a scirrhous tumour, and the lady is still in good health—at least, she was so last year. Since the operation she has married, and had children. Last year I was called to see a lady on account of another complaint, on whom I performed the operation thirteen years ago, and found that she continued free from the old disease; and, very lately, I have heard of another lady whose scirrhous breast I removed six years ago, and who continues well." The opinion of Fergusson is also very positive on this point, and he speaks in a tone with which I perfectly agree. He says: "Nevertheless, as excision gives the only chance of security—a point on which most parties seem to agree—an operation should always be resorted to, provided the knife can be carried beyond the supposed limits of the disease; and, moreover, I deem it one of the duties of the practitioner to urge the patient to submit to such a proceeding." The results obtained by Banks and Küster still further illustrate the possibility of occasionally eradicating the disease by operation. In squamous and columnar cancers the prospects of cure are very much greater if the case be taken in time.

2. If cancer cannot be actually cured by excision, may not life be prolonged and health improved by an operation?

I am decidedly of opinion that this is possible; and that, though a patient may at last be carried off by some of the recurrent forms of cancerous disease, health may be improved, life may be prolonged, and much suffering may be spared, by a timely operation. It may often be observed that, after the cancer has been removed, the digestion becomes stronger and the patient gains flesh; the colour of the complexion returns, and the spirits greatly improve, the system being relieved from a source of local irritation, and the mind from a cause of disquietude that has undermined the general health of the patient.

I think that the introduction of anæsthetic agents into operative surgery has very materially affected the bearings of this important question. So long as an operation was a source of great pain, and of much consequent anxiety and dread, a Surgeon might very properly hesitate to subject his patient to severe suffering with so doubtful a result; but now that a patient can be

freed by a painless procedure from a source of great and constant annoyance and suffering, the Surgeon may feel himself justified in thus affording him a few months or years of comparative ease, though he may be fully aware that, at the expiration of that time, the affection may return, and will then certainly prove fatal. Even under these circumstances, the patient's condition may be much improved; for the recurrent is frequently less distressing than the primary disease; since, as it often takes place in internal organs, it is not attended with the same amount of local pain and distress.

In discussing the propriety of operating in a case of cancer the Surgeon can, however, have little to do with general or abstract considerations. It will serve him little, in coming to a conclusion as to the line of practice that he should adopt, to refer to the statistics of the gross results of operations, or to general comparisons between the results of cases that are not operated upon and those that are. The whole question narrows itself to the point, as to what can best be done in order to prolong the life or relieve the suffering of the particular individual whose case is being considered. In order to come to some definite conclusion on this, it is necessary to classify the different cases of cancer, and to arrange them under the heads of those in which no operation is justifiable; those in which the result of any such procedure would be very doubtful; and those in which an operation is attended with a fair prospect of success.

Most of the following rules apply equally to true cancers and the malignant sarcomata formerly classed as such.

In no case should any operation be undertaken till the liver has been examined by percussion and palpation and found free from disease. If there are no symptoms such as cough, pleuritic pain, or hæmoptysis, it is probable that a secondary tumour in the lungs, even if present, would be too small to be recognized by any method of physical examination. Still it is always safer to examine the chest also. I have seen a case in which a Surgeon removed the upper jaw for a tumour which turned out to be a secondary scirrhus, when by palpation of the abdomen the primary tumour of the pancreas and secondary nodules in the liver could easily have been felt. I know also of another case in which the eyeball was removed for a melanotic sarcoma, when the liver was studded with secondary growths which could readily have been felt through the abdominal walls. In such cases operation is clearly improper. The urine should also in every case be examined for albumen and sugar.

Another error which the Surgeon must endeavour to avoid is that of mistaking a secondary carcinomatous deposit for the primary tumour. It sometimes happens that the primary tumour is small and so situated that it escapes the notice of the patient and the Surgeon, whilst one of the secondary deposits may present itself as a large and conspicuous growth. Thus I have known a case in which amputation was performed at the shoulder for a tumour of the upper end of the humerus which was believed to be a primary sarcoma of the bone. The microscope, however, revealed its carcinomatous nature, and subsequent examination showed that the tumour was secondary to a small carcinoma of the cervix uteri which had caused no definite local symptoms.

1. **Cases not proper for Operation.**—(*a*) It is a rule in surgery which should never be deviated from, that no operation should ever be undertaken for the removal of a malignant growth, unless the whole of the tumour and the tissues infiltrated by it can be completely removed. It is necessary to remove

not only the tumour but the surrounding tissues to some extent, even though apparently healthy. (*b*) The operation ought never to be performed in cases in which several malignant tumours exist in different parts of the body at the same time. Here the disease has evidently affected the constitution, and cannot be removed by any series of operations. In those very rare cases in which more than one primary carcinoma exists operation may, however, be undertaken if there is reasonable hope that each tumour can be completely removed. (*c*) If the cachexia be strongly marked, it is useless to remove the local affection, as probably some secondary visceral tumour is already forming. (*d*) If the tumour be of very rapid growth and soft, and its margin very ill-defined, it has probably infected the surrounding tissues so widely that it will speedily reappear in the cicatrix if removed. (*e*) If the whole of the affected organ cannot be taken away, as a bone, or if the skin or mucous membrane be so widely affected that it cannot be removed, or if lymphatic glands are enlarged which cannot be dissected out, it is useless to attempt the excision of the primary growth, as a speedy relapse will certainly ensue. (*f*) In the very chronic and indurated glandular cancers of old people, it is often well not to interfere, as in these cases the affection makes such slow progress that it does not in any way shorten life, whilst the operation might be attended with serious risk at an advanced age.

2. **Doubtful Cases.**—Those cases in which the result of an operation is extremely doubtful, but in which no other means offer the slightest prospect of relief, have next to be considered. (*a*) Malignant sarcomata of the eye, and cancers of the tongue, larynx, and testis, belong to this category; for, though more likely to return than similar affections of any other part of the body, yet they may be fit cases for operation, inasmuch as in no other way has the patient the slightest chance of being relieved of his disease. (*b*) In cancers that are already ulcerated, the Surgeon may sometimes operate in order to give the patient ease from present suffering or perhaps with a view of prolonging life; but he can have little expectation of effecting a permanent cure. (*c*) If the tumour be so large, or be so situated, that its removal cannot be undertaken without an operation so serious as to occasion in itself considerable risk to life, the propriety of operating is always very doubtful.

3. **Cases proper for Operation.**—The cases in which an operation is, in my opinion, not only perfectly justifiable, but should be urged upon the patient, are those in which the disease has originated in a person otherwise in good health, and in whom there is so far no cachexy. In schirrous carcinoma, if the disease be slow in its progress, single, distinctly circumscribed, without adhesions to or implication of the skin or glands, and more especially if it be attended with much pain, or with immediate risk to life from any cause, and if the whole of the growth, together with a sufficient quantity of the neighbouring healthy tissues, in which it is imbedded, can be removed, the case may be looked upon as a fit one for operation. If the glands are affected to a limited degree, and only to such an extent that they can be removed without danger, the operation should still be urged on the patient, provided the general health be unimpaired. In encephaloid carcinoma, or soft malignant sarcomata, the rapidity of the growth need not deter the Surgeon from operating provided the whole primary tumour and the enlarged lymphatic glands, if present, can be removed; early operation should be practised, with the view of prolonging life, if nothing more. In squamous carcinoma the removal of the primary tumour with the

glands in an early stage of infection is a more hopeful proceeding than in either of the forms of glandular cancer.

There is no fact in Surgery more certain than this, that other things being equal, *the earlier a malignant tumour is removed the better is the chance of prolonged or permanent relief.* In the preceding pages it has been pointed out how strong is the evidence that carcinoma is primarily local, and that the glands and afterwards the viscera become infected by actual particles of the tumour transplanted to them from the original growth. Accepting this as true, it necessarily follows, as was pointed out by De Morgan, that the disease may be local and capable of complete removal up to a certain moment, and the next it may have extended beyond the reach of operative interference. We cannot possibly tell when this eventful change takes place. All we can do is to try to anticipate it by operating at the earliest possible time. Not a day should be lost after the disease is recognized. In doubtful cases it is far better not to wait till unequivocal signs of the malignant nature of the growth appear, but to cut into it, and if necessary remove a slice for examination at the earliest possible time, proceeding immediately to complete removal if it is found to be malignant. Errors will arise, do what we will to prevent them, and it is far better to err by making an unnecessary incision, or even removing a mass of chronically inflamed tissue or a syphilitic gumma, than to leave a cancerous growth till its complete extirpation becomes impossible.

EXCISION OF TUMOURS.

In describing the different forms of cysts, the operative procedures necessary for their removal have been adverted to. We may now conveniently consider the steps that are generally necessary for the extirpation of solid tumours from the soft parts.

Tumours may be removed by the knife, by the écraseur, by the cautery, or by ligature.

Removal of Tumours by the Knife.—In the removal of tumours, the first point to be attended to is the arrangement, shape, and direction of the necessary *incisions*. These should not only have reference to the size of the growth, but must also be planned with due regard to subjacent parts of importance. As a general rule, they should be carried in the direction of the axis of the limb or part, and parallel to the course of its principal vessels ; they must extend not only over the whole length of the tumour, but also a little beyond it at each end : no cross-cuts should be made, if they can be avoided, and this may usually be done by attention to the proper position and extent of the linear incisions. In removing a simple tumour, no skin should, as a rule, be taken away, a simple cut being made ; but if the integumental tissues be either very abundant and loose, or adherent, an elliptical portion of them may be excised together with the tumour. In other instances, again, a semilunar flap of integument may with advantage be turned up from the tumour, the surface of which is then fairly exposed ; this, however, can be done only in some simple tumours, such as fatty growths. In excising malignant tumours the skin must in most cases be freely cut away. It is better to leave a healthy surface to heal by granulation, than not to take away any part of the skin which may be infected by the growth. The flaps covering the growth should be freely but cautiously dissected back, so as to

expose its sides and base; as these are approached, and the Surgeon reaches the neighbourhood of its more important and deeper connections, increased care will be necessary, as it not unfrequently happens that the tumour is in closer relations with deep-seated blood-vessels and nerves of a large size than would at first appear.

When practicable, the *deep dissection* will best be commenced and carried out from that part of the base of the tumour into which the principal blood-vessels appear to enter; they are thus early cut, and being once ligatured, or seized in catch-forceps, give no further trouble, which they would do were they divided from the direction of their branches towards the trunk, when at each successive stroke of the knife a fresh portion of the vessel would be touched. In carrying on this deep dissection, the operator should proceed methodically from one side of the tumour to the other, the assistants holding aside the skin so as to give as much room as possible, while the Surgeon himself, seizing the mass with his left hand, or with a large double hook or vulsellum, and dragging it well forward, uses the knife by successive strokes, but in a leisurely and careful manner, avoiding all undue haste, until he completely detaches the tumour from its connections. The safety of contiguous important structures will be best secured by keeping the edge of the knife constantly directed towards the tumour, if this be non-malignant; by attention to this rule, tumours may be removed with remarkable safety and ease from the neighbourhood of most important parts. If, however, the growth be malignant, the incisions must be made wide of the disease into the healthy structures around; unless this be done, portions of the tumour may be left from which fresh growths will rapidly sprout, or tissues apparently healthy may be left which are in reality impregnated with cancer cells.

After the tumour has been removed, it must be *carefully examined*, with the view of ascertaining whether it be entire; and, if any portions have been left, these must be properly dissected out. In some situations, as the axilla, the side of the neck, or the groin, where the relations are of great importance, the less the edge of the knife is used the better, and the growth should be enucleated by the Surgeon's fingers or by the handle of the scalpel.

In removing tumours from the neck or axilla the danger of the entrance of air into a half-divided vein, held open by the traction on the tumour, must never be forgotten. (*See* p. 489.)

The Surgeon should rarely undertake the removal of tumours that cannot be completely extirpated, as the part left will always grow with greatly increased rapidity, often assuming a fungous character; this is especially the case with malignant tumours, the rapidity of increase of which is greatly augmented by partial operations. The only exception to this rule is that a large ulcerating and necrosing mass may occasionally be removed with the view of giving the patient temporary ease.

Should, however, the Surgeon have begun the operation with the intention of removing the whole, and have been deceived as to the depth and connexions of the mass; if, for instance, he find, after commencing his operation, that the tumour extends more deeply than had been anticipated, and comes into close relation with important vessels, as at the summit of the axilla or in the perinæum, thus preventing him from dissecting it out without imminent risk of destroying the patient, the only alternative left is one that I have seen Liston adopt, and have had occasion myself to practise; viz., to throw a

strong ligature, above the apex of the growth as high up as practicable, and then to cut off everything below this. On the separation of the ligature, any portion of the tumour that has been included will be brought away as if it had been removed by the knife.

In some cases it will be found, after dividing the fascia covering the tumour, that the attachments of the growth are not so firm or deep as had previously been expected; this is especially the case in some large tumours springing from the side of the neck and the parotid region, or in the groin. The growth may then often be removed in a great measure by separating the areolar tissue with the handle of the knife, merely dividing those portions of the deeper attachments that are peculiarly dense.

If very free bleeding takes place during the operation two courses are open to the Surgeon: he may either finish the operation with the greatest possible rapidity, even perhaps cutting through outlying lobules of the growth and leaving them to be taken out afterwards, or he may arrest the bleeding as he goes on by forci-pressure forceps (p. 427) or ligature. The former plan is best if the bleeding is from multitudes of small vessels; the latter, if it proceeds from a few large trunks. In difficult dissections the parts should, when possible, be rendered bloodless. Where this is impossible the oozing is best arrested by the application of hot water (p. 420).

The wound that is left after the removal of a tumour usually unites readily by first intention if properly drained and dressed by one of the antiseptic methods described in the chapter on the treatment of wounds. If imperfectly drained, and if the cavity be allowed to become filled with decomposing discharges, severe fever and prolonged suppuration will almost certainly result.

Removal of Tumours by the Écraseur.—The écraseur was invented by

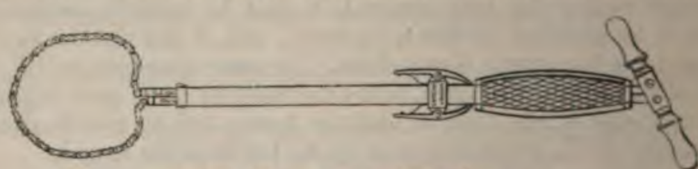

Fig. 399.—Chassaignac's Steel Chain Écraseur.

Chassaignac. It consists of a loop of chain of fine steel or twisted wire (thick piano wire is the best), which, having been passed over the tumour or through the tissues to be removed, is gradually tightened by a mechanism in the stem to which it is attached. In applying this instrument it is often necessary, first of all, to insulate and raise the tumour to be removed by passing a thread through or under it; and then, having applied the loop of the chain round its base, to tighten this and effect the strangulation by working the handle every ten or fifteen seconds, until the mass is detached.

By means of the *Écraseur* (Fig. 399), cancerous and other growths of considerable size are removed with little or no hæmorrhage, in the course of a few minutes, by a process of rapid strangulation and crushing. The resulting wound is small and puckered in, and often heals with but little trouble. If the mass to be removed be large, two or more écraseurs may be used at the same time, the chains having been passed through the tissues by means of a needle. The action of the écraseur differs according to the kind of instrument used. Chassaignac's original écraseur, armed with a steel chain,

and having a to-and-fro movement, acts likea saw. That which is now sometimes employed (see Vol. ii., Diseases of the Tongue) acts as a simple constrictor; and its use is therefore less likely to be followed by hæmorrhage. This instrument was at one time largely employed in the removal of carcinomata of the tongue, but in this and other instances it has been almost entirely superseded by improved methods of excision with the knife or scissors. Experience has not shown, as was once believed, that pyæmia is less likely to follow removal by this instrument than by the more ordinary means.

A modification of the écraseur in which the wire was heated by electricity at the same time that the noose was gradually drawn in was much in use a few years ago. The galvanic écraseur has, however, fallen somewhat into disrepute. The increased rapidity with which it cut the tissue, and the perfect absence of hæmorrhage during the operation, seemed at first great points in its favour; but experience showed that the wound left was more likely to slough, and secondary hæmorrhage occurred much more frequently than after the use of the simple écraseur.

The écraseur is undoubtedly a useful and valuable instrument, but it should never be employed when the knife can be safely used.

Paquelin's Cautery is in some cases employed in the removal of tumours. The red-hot knife of this instrument divides the tissues cleanly, and efficiently arrests hæmorrhage. The heat at which it can be used may be easily regulated, and if not raised above a dull red heat secondary hæmorrhage rarely follows its employment. In removing superficial growths, such as a carcinoma of the vulva, it can be used at a higher temperature. It then arrests the parenchymatous oozing, but leaves the large vessels spouting, so that they can easily be secured by ligature. When used at this temperature it cuts more quickly and cleanly, and chars the tissues more superficially, and leaves a surface on which a scarcely appreciable layer of slough is formed. One great disadvantage in the use of the cautery is that the charring of the divided tissues prevents the detection of fragments of an infiltrating tumour which have escaped removal.

The **Ligature** is now never used except for pedunculated growths or for nævi. It was formerly applied to small epitheliomata of the tongue, but the presence of the foul sloughing tumour in the mouth was not only unpleasant but a positive source of danger to the patient. When the ligature is applied, the part, having been well insulated, and effectually strangled by a stout whipcord ligature, sloughs and separates in a few days.

A modification known as the *elastic ligature* was introduced into practice by Dittel some years ago. It consists of a thin band of india-rubber, which is tied round the mass to be removed, and gradually tightened as it cuts its way through. It is possible that such a means may be useful in certain small pedunculated growths, which dry on being strangled; but its application to large tumours, as of the breast, is simply a revival of mediæval barbarism with the aid of modern appliances. The slowness of its action, the pain as it cuts through, the large wound that is left, the fœtor from the necrosed tumour, and the chance of septic infection from this cause, all tend to make it a method that should be avoided whenever the knife can be employed. Far more tedious, and certainly not safer than the knife, it is also inferior to caustics, which at all events arrest putrefaction, and many of which, as chloride of zinc, have a powerful antiseptic action.

CHAPTER XXXV.

TUBERCULOSIS. ACTINOMYCOSIS.

TUBERCULOSIS.

TUBERCULOSIS is an infective disease resulting from the invasion of the tissues by a specific micro-organism—the bacillus tuberculosis. The disease is characterized by the formation of chronic inflammatory tissue—the so-called *tuberculous tissue*—in the affected part; the nature of the disease can as a rule be recognized with more or less certainty by the naked-eye and microscopic characters of the lesions, but only with absolute certainty by the demonstration of the specific micro-organism. Tuberculosis is met with both as a local and a general affection. The Surgeon is chiefly concerned with the different varieties of **local tuberculosis**; and in his treatment he endeavours to arrest the disease before it has extended beyond his reach. **General tuberculosis** on the other hand is associated with the widespread development of tuberculous deposits throughout the body, and is of interest to the Surgeon chiefly as a not unfrequent fatal termination of the local forms of the disease. In the consideration of this important subject it will be convenient first to describe the typical microscopic changes presented by tuberculous tissue, and, in the next place, the naked-eye appearances to which they give rise.

Microscopic Characters of Tuberculous Tissue.—The structure which has generally been regarded as the essential element of the tuberculous lesion is the so-called *tubercle*, a small rounded nodule just visible to the naked eye. Watson Cheyne, who may justly be considered the greatest authority on the subject in this country, has however clearly shown that this view is erroneous, and that in many instances of undoubtedly tuberculous disease no "tubercles" are present. Two distinct forms of tuberculous tissue are indeed met with—the nodular form, which is characterized by the presence of discrete tubercles or "tubercle-systems" (Fig. 400), and the infiltrating form, in which no such separate tubercles exist.

The "tubercle" which is characteristic of the nodular form of tuberculous tissue is described by Cheyne as "a microscopic nodule, generally round or oval in shape, composed of a central portion made up of epithelioid cells, and sometimes giant cells, surrounded by a layer consisting of cells of inflammatory origin, or of more completely formed fibrous tissue."

The "giant cell" is usually the most striking feature of the tubercle, but it is not invariably present. It is a large, many-nucleated cell, with more or less well marked branching processes (Fig. 401). The nuclei are most commonly arranged round the outer border of the cell, or may be collected together at one end; they are large and clearly defined, of oval form, and contain one or two nucleoli. The protoplasm is coarsely granular, and often vacuolated. Around the giant cell is a zone composed of "epithelioid cells." These cells are so named from their resemblance to young squamous

epithelium; they are large and consist of granular protoplasm, containing usually a single clearly defined oval nucleus, similar to those of the giant cell. The branching processes of the giant cell can often be recognized amongst the cells of this zone. The outer part of the tubercle is composed of ordinary lymphoid corpuscles, differing in no respect from the migrating leucocytes observed in other forms of inflammation. These cells are readily distinguished from the epithelioid cells by their small size and their behaviour to staining reagents, by which they are much more deeply coloured than the epithelioid cells. Some difference of opinion exists as to the presence of a reticular stroma between the cells of the outer zones; Watson Cheyne, who has paid especial attention to this point, has not been able to demonstrate any reticulum beyond such as is formed by the branching processes of the giant cells and by "bands of fibrous tissue in connection with the wall of the tubercle." The appearance of a fine reticulum may also be produced by coagulation of a homogeneous intercellular substance by the reagents used in hardening the specimen. No

Fig. 400.—A group of Tubercle Nodules in a mass of soft granulation tissue from a tuberculous knee.

Fig. 401.—A Tubercle Nodule more highly magnified, showing a giant cell surrounded by epithelioid cells and lymphoid corpuscles.

vessels penetrate amongst the cells, and this want of vascularity forms one of the most important and distinctive features of tubercles. In the condition known as "tuberculous infiltration" no discrete tubercles are present, but epithelioid cells with or without giant cells are scattered irregularly or in broad tracts through the affected tissue. Baumgarten and Cheyne have independently arrived at the conclusion that the epithelioid cell is the most characteristic element of tuberculous tissue. The lymphoid cells differ in no respect from those met with in simple inflammation, whilst the giant cells are not invariably present. The epithelioid cells on the other hand are constantly present, and, as we shall see, it is in association with them that the bacillus is most usually found. It must, however, be remembered that very similar cells are met with in other chronic inflammatory processes. Ziegler and Tillmanns have also shewn that similar cells are produced when granulation tissue is made to grow between two thin glass slides inserted into the peritoneal cavity or beneath the skin of a rabbit; these cells, which Ballance and Sherrington, in repeating Ziegler's experiments, speak of as "plasma cells," have already been described in the chapter on Repair.

The giant cells of tubercle present certain peculiarities which usually make it possible to identify them with some degree of certainty. There are four forms of multinuclear cells from which they have to be distinguished: first, those of simple chronic inflammation; secondly, those of syphilitic growths; thirdly, the large cells found in the destructive processes in bone (osteoclasts); and, fourthly, the many-nucleated cells of a myeloid tumour. From the first and second they may commonly be distinguished by their greater size and by the processes extending from them into surrounding parts. Osteoclasts are smaller, have no processes, and lie in immediate contact with the bone, filling a hollow in its substance (Howship's lacuna), while a tuberculous giant cell is always surrounded by leucocytes. In myeloid cells the masses often reach a great size and the protoplasm is less granular. The great distinctive feature however is in the arrangement of the nuclei. In all forms of giant cell, except the tuberculous, the nuclei are scattered more or less uniformly through the protoplasm; in the tuberculous they are gathered together either at the circumference or at one end or at both with their long axes directed more or less uniformly towards the centre of the cell.

The observations of Villemin, Wilson Fox, Cohnheim, and many others, had shown clearly that tubercle is an infective process, but the whole subject was involved in great obscurity till in 1882 Koch, by a new method of staining, discovered in the tuberculous tissue a specific microscopic organism to which he gave the name of *bacillus tuberculosis*. It is a non-motile, rod-shaped fungus with a slight longitudinal curve, and about equal in length to one-third of the diameter of a red blood-corpuscle, and its breadth is about one-fifth of its length. Clear bright dots are often seen in it which there is every reason to believe are spores.* The bacilli are found in the giant-cells, and in or among the epithelioid cells. In slowly growing tubercle the organisms are very few in number and almost exclusively contained in the giant cells, sometimes only one in each. Under these circumstances it is evident that the bacilli can be discovered only with great difficulty, and unless the section through the giant cell happens to hit the exact situation of the organism, and to be parallel to its long axis, it may appear that none is present. In more acute processes the cell may be crowded with bacilli (Fig. 402), and they may burst beyond its limits extending amongst the surrounding epithelioid and lymphoid cells. Koch has demonstrated the curious fact that the nuclei of the giant cell lie as far removed from the bacillus as possible, so that the idea involuntarily arises in the mind that there must be some kind of antagonism between them and the parasite.

Fig. 402.—Tubercle Bacilli in a Giant cell.

The proof that the bacillus is the actual virus of tubercle has been obtained in the same manner as in the case of other pathogenic organisms. Its presence has been demonstrated in the diseased tissues, first by microscopic observation, and secondly by cultivation experiments. The bacillus has been cultivated

* For the details of the mode of preparation and cultivation of the bacillus of tubercle the reader is referred to Koch's paper, translated by Boyd (Micro-organisms in Disease. New Sydenham Society, 1886) and to Crookshank's Bacteriology.

to many generations out of the body, and then inoculated on animals with the effect of giving rise to genuine tubercle, in which again the organism was found on microscopic examination. The media which have been chiefly employed are solidified blood-serum, and agar-agar peptone to which 6 or 8 per cent. of glycerine has been added. Cultivation from human tubercle is not easy, and requires much special management and apparatus, and in many tuberculous diseases it is very difficult to find the bacillus by the microscope. Its presence has, however, been proved by the inoculation of the doubtful material into the anterior chamber of the rabbit's eye. This is followed, if the bacillus is present, by tuberculous disease of the iris, and subsequently by general tuberculosis, the bacillus then being found in the diseased tissues. This method is free from error, as the rabbit's eye is never the seat of spontaneous tuberculous disease.

The explanation which may be given of the process up to this point is, therefore, that the bacillus, either in its fully developed state, or as a spore, becomes lodged at the point at which the tubercle subsequently forms. It may come there by the blood or lymph stream, and is possibly carried by a white blood-corpuscle which has taken it up into its substance. When it lodges it causes a local irritation, and the formation of the tubercle represents the effort of the tissues to expel or destroy the invading parasite. The first effect of the irritation is to cause an abundant migration of leucocytes from the surrounding vessels. At the same time some proliferation of the fixed tissue cells occurs, and thus the epithelioid cells are formed, in large measure no doubt from the endothelium of the small blood-vessels and lymph spaces. Many views have been expressed concerning the origin of the giant cells. It has commonly been believed that they are formed by fusion of a number of leucocytes round the bacillus. That such a process is possible is suggested by the observations of Metchnikoff on certain molluscs in which he watched the fusion of cells round bacilli experimentally introduced. Other views have, however, been held as to their origin, and Treves has maintained that they are merely lymph-coagula enclosing some of the smaller cells. Cheyne believes that the giant cells are derived from the epithelioid cells either by hypertrophy of individual cells or by coalescence of neighbouring cells. The lymphoid cells around are merely migrated corpuscles. If the cells destroy the bacillus the process comes to an end, the migrated cells disappear, and repair takes place in the ordinary way, probably from the original cells of the part, a small fibrous nodule remaining in the site of the tubercle. If the bacillus overpowers the cells, it multiplies, and subsequently spreads by invasion, into the surrounding parts. The evident irritation of the tissues round the bacillus is supposed to be due to the chemical products formed by the organism in its growth.

If the morbid process continues to advance, the next change observed in the tubercle is the fatty degeneration of the central part. Granules appear, first clouding the cells and obscuring the nuclei, and subsequently complete degeneration takes place, and the central part of the tubercle becomes merely a granular cheesy mass in which no cell structures are recognizable. In the process of degeneration the lymphoid corpuscles become withered and shrunken and granular before complete disintegration. In this state they were observed by Lebert and believed to be characteristic of tubercle, and hence he named them Tubercle-Corpuscles. This is the process of **Caseation of Tubercle.**

It has been asserted that this caseation may be the result of a simple chronic inflammatory process arising from various causes, and that the bacillus finds a nidus for its growth in the degenerated tissues. Koch distinctly denies this. He asserts that the bacilli can be recognised only before caseation takes place, and that as degeneration progresses they either perish or break up, leaving their spores behind. That the latter is probably the case is shown by the fact that although no bacilli can be recognised in the cheesy mass, it still retains its virulent properties when inoculated on an animal. Two causes probably determine the caseation of tubercle: it is partly due, no doubt, to insufficient blood supply resulting from the absence of any newly formed vessels; and secondly, it is thought probable that it is also caused by various irritating chemical substances produced by the bacillus.

Even after caseation recovery may take place. The bacillus may perish, the cheesy nodule may gradually become dryer and firmer and be encapsuled in a zone of fibrous tissue formed from the surrounding parts; or lime salts may be deposited in it and it may become calcified, and this may remain harmlessly imbedded in fibrous tissue. In bone it may be surrounded, according to Nélaton, by a thin capsule of dense osseous tissue.

In other cases, after caseation, it may soften, inflammation and suppuration may occur round it, and it may be expelled as a foreign body. However widely the tuberculous process spreads, it consists merely of a repetition and extension of the changes here described. The more acute the process the less clearly will the individual nodules be marked, and the more it will take the form of a uniform small-celled invasion of the surrounding structures. If the morbid process continues to extend, invading surrounding parts, it often causes extensive destruction of tissue.

The **Extension of Tubercle** takes place in various ways. It is, of course, evident that it can occur by direct infection of contiguous parts. The bacillus itself is non-motile and cannot migrate, but Koch believes that the organism may be taken up by wandering cells which subsequently enter the lymph stream and are thus carried to other parts, either near the original focus or at a distance, bearing the organism with them. The actual presence of bacilli in the corpuscles has been demonstrated by Koch after injection of the organism into the blood-stream. In this way we may find the new tubercles dotted closely round the primary focus. The well known frequency with which the disease implicates the nearest lymphatic glands is further evidence of this mode of propagation. Again, it easily spreads over a surface such as the synovial membrane of a joint or a mucous membrane. Thus we see in white swelling of the knee that after infection of the joint from a small tuberculous centre in the bone the whole synovial surface quickly becomes affected, and in tuberculous disease of the kidney we find infection of the ureter and bladder.

Lastly, the virus may enter the blood-stream, and general dissemination occur throughout the body as an acute disease. There is no reason to believe that this ever occurs as a primary condition, or that it is due to an infection of the blood, and to an increase of the virus in the blood. Tubercle is always primarily a local disease, and although the virus may be disseminated by the blood, it probably does not multiply in it. The acute disease is due to the entrance into the blood-stream of softened tuberculous matter from a local centre, either indirectly through the lymphatics or directly through the veins.

It then gives rise to the formation of tuberculous tissue in various situations throughout the body. Each tubercle is surrounded by its zone of irritation, and thus in a membrane we may get an apparently diffuse inflammation as in tuberculous meningitis. It is probable that some constitutional condition is necessary for the development of acute tuberculosis as well as the local source of infection, for it seems most likely that in all local tuberculous diseases the virus must frequently enter the blood-stream, and yet acute general tuberculosis is not a common termination of local disease.

From the foregoing description, therefore, it will be seen that tubercle is a form of chronic infective inflammation caused by the invasion of the tissues by the bacillus tuberculosis; it gives rise to the formation of non-vascular cellular nodules, destroying and occupying the place of the original tissues of the part in which they lie. It spreads locally by invasion of surrounding parts, and by the lymph or blood-stream to distant parts. The actual tuberculous tissue is incapable of higher development; its natural tendency is to fatty degeneration, after which it may dry up and remain unchanged; it may calcify or it may soften. Its presence causes irritation of the surrounding tissue beyond the actual tuberculous area. This is accompanied by hyperæmia and various other changes according to the intensity of the local process and the resisting power of the tissues. Thus around the tubercle we may have chronic overgrowth of fibroid tissue, rapid formation of vascular granulation tissue, acute inflammation with exudation as in tuberculous meningitis, and even suppuration. Tubercle may be fatal by its local effects on vital organs, as in pulmonary phthisis, by the exhaustion following suppuration round local centres as in tuberculous diseases of bones or joints, or by general acute infection or acute tuberculosis. It may be recovered from by degeneration and by being encapsuled in fibrous tissue, by caseation and calcification and subsequent encapsulation, or by softening and suppuration and elimination from the body. Whether the organism is completely destroyed, or whether its spores remain encapsuled in the healed tissues, we do not know.

We are now in a position to consider the clinical features and the morbid anatomy of tuberculous affections.

Naked-Eye Appearances of Tubercle.—In the description of these, we must here confine our attention to tubercle as it comes under the care of the Surgeon, omitting all mention of the lungs. A single tubercle follicle forms a minute dot just visible to the naked eye; it is semi-transparent and grey in colour, and of cartilaginous hardness, and it has received the name of the *semi-transparent grey granulation*. By an increase in the zone of lymphoid cells, or by the close approximation of two or more separate nodules, the grey granulations frequently reach the size of a millet-seed, and have consequently received the name of miliary tubercle (*milium*—millet). The grey granulation has long been considered the most characteristic feature of tubercle. It is commonly surrounded by a zone of hyperæmia, and often by distinct evidence of inflammation. Thus on a serous membrane it may be covered by a thin layer of lymph, and the cavity lined by the membrane may contain an excess of fluid. In joints it may be surrounded by a zone of granulation tissue before which the normal structures are disappearing. In some cases, instead of forming distinct nodules, tubercle infiltrates the tissues in a single mass. This is often seen in the testicle when the disease is advancing from the epididymis into the body. Here there may be a hard semi-transparent zone more than an eighth

of an inch in breadth, which on microscopic examination is found to be composed of tubercle nodules, so closely packed as to be practically continuous. (See Figure of Tuberculous Testicle, Vol. II.) This is termed *grey infiltration*. Beyond this dotted grey granulations may be seen in the otherwise healthy tissues.

Before it reaches any considerable size the grey granulation undergoes fatty degeneration. It becomes opaque in its centre, yellowish-white in colour, and more friable in structure, and is then termed *Yellow Tubercle*. By the process of invasion of the surrounding tissues by the tuberculous growth, followed by fatty degeneration and caseation, large cheesy masses may be formed. These commonly reach the size of a pigeon's egg, and are often larger. Thus a lymphatic gland by gradual tuberculous invasion and destruction of its normal tissue, followed by fatty degeneration, may be converted into a yellow cheesy mass, closely surrounded by the stretched capsule. The kidney in like manner may be converted into a huge cheesy mass bigger than a fœtal head. Caseated tubercle is soft and brittle, so that it can easily be removed from the cavity in which it is lying, by means of a sharp spoon. This, as will be subsequently seen, distinguishes it from a softening syphilitic gumma, which is leathery and tough.

The fate of these large caseous masses varies. They may either dry up and become firm and be encapsuled, or they may calcify or soften. The particular change that a mass of yellow tubercle undergoes seems to depend in part at least on the situation of the disease. Thus calcification is common in the bones and lymphatic glands, but is rarely, if ever, met with in the skin, testicle, kidney, or synovial membranes. Encapsulation by fibroid tissue is common in the lymphatic glands, and is occasionally met with in the kidney; softening is the rule in the skin, testicle, kidney, and synovial membranes, and is very common in the lymphatic glands.

By the progressive development of tuberculous tissue with the inflammatory changes around it, the normal appearance of the affected part becomes entirely lost, and it is converted into a soft pulpy mass of **Tuberculous Granulation Tissue.** In this the grey or yellow tubercles can often be recognized with the naked eye.

When tubercle softens it breaks down into a thick curdy fluid. The process is always accompanied by more or less inflammation of the surrounding parts, accompanied in most cases by the formation of pus, and we have thus formed the **Tuberculous Abscess.** This is the most common form of chronic abscess. It may form a large collection of fluid—sometimes, as in the psoas abscess, reaching an enormous size. The fluid it contains is commonly thin and curdy, and contains much granular matter and but few recognizable pus cells. In more acute cases the pus may more closely resemble that of an acute abscess. The wall of the abscess may be composed of a thin layer of caseating tubercle. This is the case in tuberculous abscesses of the kidney, testicle, or skin. In the larger abscesses, such as a psoas abscess, it may be in part formed merely by condensed fibrous tissue not actually tuberculous. Bacilli can scarcely ever be demonstrated in the pus of these abscesses by microscopic examination or direct cultivation, but that their spores are present can be shown by inoculation experiments.

In superficial tuberculous diseases, after softening of the tubercle and discharge of the softened cheesy matter, an ulcer is often left.

The **Tuberculous Ulcer** is usually characterized by the following features: The floor of the ulcer is yellow and granular, the base is slightly indurated, and the edges raised and often undermined. It tends to spread slowly by progressive infection of surrounding tissues. In surgical practice we meet with such ulcers in the skin, bladder, rectum, tongue, and larynx. In these the progress of the disease is often hastened by the decomposition of the discharges from the sore.

Constitutional Symptoms of Tuberculous Diseases.—Local tuberculous diseases are not necessarily accompanied by any recognizable constitutional symptoms, even though many different local centres of tubercle exist. When, however, tubercle exists in a considerable local mass, as in the kidney or testicle, or in a diseased joint, and more especially when it is commencing to soften, careful thermometric observations will almost always show some elevation of temperature, especially at night. This may not be great, perhaps not up to 100° F., but if it is persistent, it is very grave evidence of softening tubercle. The consideration of the symptoms of general tuberculosis belongs rather to Medicine than to Surgery. When visceral tuberculosis occurs as a secondary consequence of a local tuberculous disease it most commonly appears in the form of ordinary pulmonary phthisis, and runs the usual chronic course. Progressive emaciation, evening elevation of temperature and night sweats, which cannot be accounted for by prolonged suppuration from the local seat of disease, always lead to a grave apprehension that general tuberculosis is taking place.

In cases of acute general tuberculosis following a local tuberculous disease, such as are occasionally met with in joint disease and more often in tuberculous testicle, there is marked febrile disturbance, the thermometer reaching often 103° F. or 104° F., without, at first, definite affection of any organ. The symptoms may then closely resemble typhoid fever, or if there is an open wound, may be mistaken for septicæmia. Before long, usually not later than the second week, symptoms either of acute pulmonary phthisis, tuberculous meningitis, or some other definite tuberculous affection, make their appearance.

Special Tuberculous Diseases.—The only certain evidence that a disease is tuberculous is the presence of the bacillus tuberculosis in the diseased tissues, proved either by direct microscopic observation, by cultivation, or by inoculation. The general course of the disease, the invasion of the tissues by a chronic inflammatory new growth, incapable of higher development, and tending always to caseation, and the occasional termination in general or pulmonary tuberculosis, are secondary proofs, but cannot be considered conclusive in the absence of the demonstration of the bacillus.

The following surgical diseases have been proved more or less conclusively to be tuberculous:

(*a.*) Skin and subcutaneous tissue: lupus, and subcutaneous scrofulous abscess; (*b.*) Mucous membranes: tuberculous ulceration of tongue, pharynx, palate, and larynx; some cases of scrofulous ozæna and fistula in ano; (*c.*) Lymphatic glands: many cases of strumous enlargement and scrofulous abscess; (*d.*) Genito-urinary organs: scrofulous kidney, strumous testicle, and some forms of ulceration of the bladder, and scrofulous disease of the prostate and vesiculæ seminales; (*e.*) Bones and joints; all cases of white swelling, or fungous disease; many of chronic synovitis; almost all, if not all, cases of caries, not evidently traumatic, septic, or syphilitic; chronic abscess of bone,

and some forms of chronic osteomyelitis ; fungous disease of sheaths of tendons, and some forms of chronic teno-synovitis. This long list shows the truth of Volkmann's remark that since the true nature of these diseases has been recognized, the Surgeon may almost be said to have more to do with tubercle than the Physician.

Predisposing Causes of Tuberculous Disease.—Tubercle being a specific infective disease it follows, as in the case of the infective diseases generally, that the predisposing causes are of two kinds : first, those which favour the entrance of the specific virus into the body ; and secondly, those which lessen the resistance of the tissues, either locally or generally, to the growth of the virus.

The path by which the virus originally enters the body is somewhat doubtful. The bacillus can be cultivated out of the body only with considerable difficulty, requiring a temperature of from 80° to 105° F., and growing only on blood-serum. It is probable, therefore, that it is a genuine parasite, and exists out of the body only in the form of spores. These spores are contained in the sputa of phthisical patients, in the fæces of those suffering from tuberculous diseases of the bowels, and in the urine of those affected with genito-urinary tuberculosis. Many of the lower animals are also liable to tubercle, and may disseminate the virus. Thus the milk of cows suffering from tuberculous disease of the udder is undoubtedly a most important source of infection ; tubercle bacilli have been demonstrated in the milk, and tuberculosis has been produced by inoculation. The risk of infection by meat from tuberculous animals is probably small. Judging from the analogy of the bacillus anthracis, the spores in all probability retain their vitality for years when dried, and may be diffused everywhere where dust is carried, and there can be little doubt that they are abundant in the dust wherever human beings are crowded together. In all probability we have all frequently taken them into our bodies, but fortunately they can develop only where they find favouring general and local conditions.

A considerable number of cases have now been recorded in which *direct inoculation* of wounds by the tuberculous virus has occurred. Elsenberg has collected thirteen cases in which tubercle appeared to have been directly inoculated during the rite of circumcision. Eve has recorded a remarkable case of the same kind. A child aged five months was admitted into the London Hospital with a large abscess containing caseous pus in each groin, and a small sore on the frænum which had remained unhealed since circumcision had been performed on the eighth day after birth. Inoculation of a guinea-pig with pus from one of the abscesses produced tuberculosis. The individual who had performed the circumcision had died of phthisis a week before the child was admitted to the hospital, and another child whom he had circumcised a year previously had died of tubercle.

A striking case of direct inoculation is recorded by Tscherning of Copenhagen. A healthy woman aged twenty-four cut her finger with a broken glass vessel containing the sputum of a man dying of phthisis. A small fungating mass of granulation tissue formed, and was scraped with a sharp spoon. The disease recurred, and subsequently the finger was amputated, and swollen glands at the elbow and in the axilla excised. The sputum which was the source of inoculation was rich in tubercle bacilli, and the granulation tissue from the finger and the enlarged glands contained tubercle nodules and bacilli.

The occasional transmission of tuberculosis by *contagion* is of interest chiefly in connection with tuberculous affections of the lungs.

Constitutional Predisposing Causes.—Under this heading must be included the various conditions, mostly little understood, which diminish the resisting power of the tissues to the invasion of the tubercle bacillus. Of these the most important is undoubtedly the constitutional condition known as **Scrofula** or **Struma.** Scrofula is characterized, as Virchow expresses it, by an "abnormal vulnerability" of the tissues, or, in other words, by a subnormal resistance to external injurious influences, amongst which must be included the invasion of pathogenic organisms of all kinds. Scrofula is not a disease; it is merely a constitutional predisposition to disease, and not to one disease only, but to many. If we study the diseases of those patients who present the characters to be presently described as those of the scrofulous diathesis, we shall find that it is not to tubercle alone that they show an abnormal susceptibility. Scrofulous patients as a rule suffer more severely from syphilis, should they contract that disease; gonorrhœa with them is difficult to cure; and buboes commonly follow a soft chancre. Scrofulous children are more likely than others to die of scarlet fever or measles; and it is a generally received opinion, though there is no very good evidence for it, that they are more liable than others to acute infective periostitis and necrosis of bone.

The scrofulous diathesis is characterized chiefly by a tendency to various forms of inflammation, resulting from slight causes which would be innocuous to healthy subjects. Catarrhal inflammations of mucous membranes are especially common. Micro-organisms multiply in the discharges, and the further irritation of the products of their growth causes the discharge to become purulent; and, owing to the feeble resisting power of the tissues, the condition may be very chronic. Scrofulous catarrhal inflammation in children is especially likely to attack the eye, nose, throat, and ears. The *conjunctiva* becomes chronically inflamed, and the discharge becomes muco-purulent. As a sequela of this the condition known as "granular lids" is not uncommonly set up. The papillæ become excessively vascular and hypertrophied, till the whole surface of the membrane appears to be covered with genuine granulation tissue. The affection specially known as strumous or phlyctenular ophthalmia often leads to the formation of a small, intractable ulcer on the cornea, with intense injection of the surrounding conjunctiva.

The *mucous membrane lining the nostrils* becomes chronically congested, red and swollen, giving rise to habitual sniffing and to a sensation as of a constant cold. The discharge, at first merely mucous, frequently becomes purulent, and lodging in the irregularities of the nasal fossæ, decomposes, giving rise to the most offensive smell. This condition, known as *strumous ozæna*, may sooner or later cause ulceration of the membrane and subsequent necrosis of the bones. Occasionally the lining membrane of the antrum becomes irritated, and this may be followed by enlargement of the cavity and discharge of unhealthy pus into the nostrils.

The *mucous membrane of the throat* is chronically congested, and the adenoid tissue of the naso-pharynx is often hypertrophied; the tonsils may be enlarged.

Chronic purulent discharge from the ear, *scrofulous otorrhœa*, is another very common affection. The disease most frequently commences in the middle ear, the discharge finding its way out by perforating the membrana

tympani. It frequently leads to destruction of the ossicles and permanent deafness. The mucous membrane of the *genito-urinary organs* also is readily affected with purulent catarrh, often arising from very slight causes and very permanent. Such discharges are of common occurrence in female children, and have frequently given rise to unfounded charges of criminal assault.

The *lymphatic glands* are peculiarly prone to be affected, and the enlargement can almost always be traced to some irritation of the part from which they receive their lymph supply.

These various strumous inflammations undoubtedly render the part affected peculiarly liable to become tuberculous. As an instance may be mentioned the very common cases of tuberculous disease of the lymphatic glands of the neck occurring in strumous children. Here it may fairly be supposed that the unhealthy condition of the mucous membrane of the throat favours the entrance of the bacillus tuberculosis, which, reaching the already inflamed lymphatic gland, finds the soil ready prepared for its growth.

A reference to the list of surgical tuberculous diseases given on p. 1093, will show that many affections previously spoken of as strumous or scrofulous have been definitively proved to be actually tuberculous. The terms "scrofulous" and "tuberculous" are not indeed synonymous. A patient may be scrofulous and yet suffer from no actual disease; he cannot be tuberculous, unless his body is actually invaded by the bacillus.

Signs of the Scrofulous Diathesis.—The existence of the scrofulous diathesis is often marked by the presence of a peculiar temperament.

The **Scrofulous Temperament** assumes two distinct forms, the fair and the dark; and each of these presents two varieties, the fine and the coarse. The most common is that which occurs in persons with fair, soft, and transparent skin, having clear blue eyes with large pupils, light hair, tapering fingers, and fine white teeth; whose beauty indeed is often great, especially in early life, being dependent rather on roundness of outline than on grace of form; and whose growth is rapid and precocious. In these individuals the affections are strong, and the procreative power considerable; the mental activity is also great, and is usually characterized by much delicacy and softness of feeling, and vivacity of intellect. Indeed, it would appear that, in such persons as these, the nutritive, procreative, and mental powers are rapidly and energetically developed in early life, but become proportionately early exhausted. In another variety of the fair scrofulous temperament, we find a coarse skin, short and rounded features, light grey eyes, crisp and curling sandy hair, a short and somewhat ungainly stature, and clubbed fingers; but not uncommonly, as in the former variety, great and early mental activity, and occasionally much muscular strength.

In the dark form of the scrofulous temperament, we usually find a somewhat heavy, sullen, and forbidding appearance; a dark, coarse, sallow, or greasy-looking skin; short, thick, and harsh curly hair; a small stature, but often a powerful and strong-limbed frame; with a certain degree of torpor or languor of the mental faculties, though the powers of the intellect are sometimes remarkably developed. The other dark strumous temperament is characterized by clear dark eyes, fine hair, a sallow skin, and by a mental and physical organization that closely resembles the first described variety of the fair strumous diathesis.

In all these varieties of temperament, the digestive organs will be found to

be weak and irritable. This condition, which I believe to be invariably associated with the scrofulous diathesis, and the importance of which was pointed out by Sir James Clark, must be regarded as one of the most essential conditions connected with scrofula, and as tending greatly to that impairment of nutrition which is so frequent in this state. This gastric irritability is especially characterized by the tongue, even in young children, being habitually coated towards the root with a thick white fur, through which elongated papillæ project, constituting the "pipped" or "strawberry" tongue; the edges and tip, as well as the lips, being usually of a bright red colour. This state of the tongue is aggravated by stimulants, high living, and the habitual use of purgatives. In the fair varieties the bowels are usually somewhat loose, but in the dark forms of struma there is a torpid condition of the intestinal canal. In all cases the action of the heart is feeble, and there is a tendency to coldness, and often to clamminess of the extremities.

The *Hereditary Nature* of tuberculosis is well known to the public and to the profession; for although the scrofulous diathesis is not commonly congenital, yet the tendency to it is, and it often manifests itself at an early period. In other words it seems probable that tuberculosis itself is not inherited, but only that "abnormal vulnerability" of the tissues which renders them peculiarly liable to tuberculous diseases.

A most powerful occasioning cause of the scrofulous diathesis and ot tuberculous disease, and that which in most civilized countries is likewise the most frequent, is *malnutrition* arising from an habitual disregard of hygienic laws: either from insufficiency of nourishment, or the administration of improper food, in the poorer classes; or from overfeeding, and overstimulation of the digestive organs, amongst the children of the wealthier orders of society, inducing chronic irritation of the mucous membrane of the stomach and interference with the digestive powers, and consequently with nutrition. The influence of food that is innutritious in quality or insufficient in quantity, was shown by Phillips, in his excellent *Treatise on Scrofula*, to be the most immediate cause of the diathesis; and, when conjoined with the injurious effects of a confined and impure atmosphere, it may be considered as sufficient to occasion it in those cases in which no predisposition to it exists, and greatly to develop any hereditary tendency to it in the system. It is to the conjoined influence of agencies such as these that we must attribute the prevalence of tuberculous diseases amongst the lower orders both of town and of rurai populations.

Tuberculous affections of various kinds are often called into activity by the *debility induced by previous diseases*, such as measles, scarlatina, whooping-cough, &c.

Excluding affections of the lungs, tuberculous diseases usually develop at *an early age*, though seldom before the child has reached its second year. They are most common about the period of the second dentition, and it is comparatively rare to meet with them for the first time after the ages of twenty-five or thirty-five. *Sex* does not appear materially to influence the disease.

Local Predisposing Causes.—Although certain constitutional conditions are of great importance as predisposing causes of tuberculosis, yet cases of tuberculous disease are very frequently met with in patients who present none of them. Under these conditions the diminished resisting power of the tissues is local and not general, and as common causes of such local diminished

resistance may be mentioned previous simple inflammation and damage by slight external injury. Thus in many cases of tuberculous joint disease the history clearly points to a sprain or other injury as the starting-point of the disease.

The local effect produced by tuberculous infection varies very greatly under different circumstances. It has been pointed out in the Chapter on Inflammation that the effect of an irritant varies, first, with the intensity of the irritant itself; secondly, with the resisting power of the tissues, and thirdly, with the presence or absence of accessory sources of irritation.

The variation in the local effect of the virus is, perhaps, best illustrated by tuberculous disease of the synovial membrane of the knee. In tolerably healthy adults a few tubercle nodules may form in a limited part of the membrane and there give rise to a chronic inflammatory growth of fibrous tissue around them, the mischief remaining strictly limited and its nature being ascertainable only by the microscopic evidence of a few atrophied nodules in the mass of fibroid tissue. In children we more commonly find the disease extending rapidly; implicating the whole membrane and giving rise to the formation of a mass of soft, pulpy, vascular granulation tissue, scattered through which are numerous non-vascular tubercle nodules which are the centres of irritation which have caused the growth. If such a joint be now put at rest and every accessory source of irritation removed, and the child be well fed and removed to pure air so that the resisting power of the tissues is increased, we find the vascular granulation tissue developing into firm fibroid tissue which encloses the tubercle nodules, and thus recovery takes place. If, on the other hand, the child be neglected and the joint moved, we find the tubercle invading the granulation tissue and replacing it and finally degenerating and softening and thus giving rise to a chronic abscess. If such a joint be opened and decomposition follows, it is possible that the irritation of the septic matter may cause rapid sloughing of all the tuberculous tissue and thus bring the specific disease to an end; but the reverse may occur. The resistance of the tissues may be still further impaired by the irritation of the septic products, and the invasion of the bones by the bacillus may be hastened. If these facts be borne in mind it is not difficult to understand how the presence of tubercle may be associated with all varieties of the inflammatory process, chronic fibroid growth, exuberant formation of granulation tissue, suppuration, ulceration, or even sloughing.

The part played by the constitutional and local predisposing causes varies in different cases. In some diseased joints rest alone is quickly followed by cure; in others local treatment has no effect and the invasion of the bacillus continues unchecked.

Senile Tuberculosis.—Middle-aged and elderly people are occasionally attacked by tuberculous diseases. The individuals so affected have usually suffered from similar disease in their youth, or have come of scrofulous families. But the disease has apparently been cured, and they may have enjoyed good health and led active lives for a long series of years. Under the influence of depressing physical or mental causes, or as the result of debility consequent on some serious illness, typical symptoms of tubercle will manifest themselves in the soft parts, the joints, and the bones. The disease may run an acute course, and the patient will die of tuberculosis of some of the organs.

TREATMENT.—**Preventive Treatment** is that intended to prevent the

development of tuberculous disease in those who present the external signs of the scrofulous diathesis, or who have an hereditary tendency to it. It is of the utmost consequence, and by proper attention to it, I have no hesitation in saying, the development of local disease, even when there is hereditary predisposition, may be stopped; and the child of strumous parents, presenting perhaps the features indicative of the diathesis, may pass through life without the disease having an opportunity of declaring itself. In order to accomplish this, however, the preventive plan of treatment must be commenced early, and continued uninterruptedly for a considerable time, even for years.

The preventive treatment of scrofula and tubercle may be said in general terms to consist in close and continuous attention to hygienic rules. The diet must be specially attended to; nourishing food, but of the lightest quality, being given. A great error is often committed in overloading the stomach with more or with heavier food than it can digest, under the impression that strong food is necessary to give the patient strength. In consequence of this error, the irritability of the mucous membrane is kept up, nutrition is imperfectly performed, the surplus food is thrown off in the shape of lithates, or other products of mal-assimilation, and health and strength, which are the results of perfect nutrition, become impaired rather than improved. The use of stimulants, whether wine or beer, should be very sparing, and the milder and weaker should be preferred to the heavier and stronger kinds of malt liquor; the bowels must be kept regular with the simplest aperients; the clothing should be warm, and must cover the whole of the surface; and the patient should live in well-ventilated rooms. He should be allowed sufficient exercise in the open air, not carried to the point of fatigue, and should, if his circumstances permit, have change of air from time to time, alternating a sea with an inland climate. Bathing also, whether in sea or river, with the habitual use of the tepid or cold sponge-bath, and friction of the surface with horse-hair gloves or a rough towel, so as to keep the skin in healthy action, should be regularly practised. In carrying out this general plan of treatment, it must be borne in mind that though the health and strength of a delicate and weakly child can be improved up to a certain point, it can never, by any means, be rendered as robust and vigorous as a child of good congenital stamina who had been equally well cared for.

The **Curative Treatment** is General and Local. The general treatment should, like the preventive, be specially directed to the improvement of the nutrition, and through it to the augmentation of the constitutional vigour of the patient; all those hygienic means that have just been alluded to being continuously carried out.

The more strictly medical treatment of scrofula consists in the administration of tonics and alteratives with the view of improving the patient's constitutional powers. Before they are administered, however, it is always necessary to see that the digestive organs are in a healthy condition. Scrofula is a consequence of malnutrition; and unless we see that digestion, the first stage of the nutritive process, is properly accomplished, all other means will be useless. When the tongue is covered with a white, thick, creamy fur, and has elongated papillæ and red edges, neither purgatives nor tonics can be largely administered. In these circumstances the patient should be confined to the mildest possible diet, which must principally consist of milk, boiled fish, white meats, and light pudding, no stimulant of any kind being allowed except a small

quantity of claret or bitter beer: and, unless the patient have been accustomed to the use of stimulants, even these had better be dispensed with. Small doses of mercury with chalk, of soda and rhubarb, should be occasionally administered at bed-time, with some of the compound decoction of aloes on the following morning; and a few grains of the carbonate of soda or of potash may be given twice or thrice a day in some light bitter infusion, as of cascarilla or calumba. In many cases of tuberculous disease, more especially that affecting the joints and bones, the liver will be found to be enlarged and sluggish in its action, the patient every now and then becoming bilious, sallow, and jaundiced; in these circumstances, small doses of blue pill, carried off with the compound decoction of aloes or a rhubarb draught, will be found necessary from time to time. When all gastric irritation has been removed in this way, or if it have not existed in the usual marked degree from the first, the patient being pale and flabby, with a weakened condition of the pulse, of the skin, and of the mucous surface, then tonics may be administered, and the more specific treatment adopted.

The great remedies which are employed in the constitutional treatment of scrofula are iron, iodine, the preparations of potash, and cod-liver oil. These are all extremely useful, either singly or conjoined, as they serve to carry out distinct indications in the management of this affection.

Iron is most useful in improving the nutrition of pale, flabby, anæmic subjects. The best preparations for children are, I think, the vinum ferri and the syrup of the iodide of iron. In older persons the tincture of the perchloride, and some of the forms of the citrate or the phosphate of iron, appear to be most serviceable; in other cases, again, the natural chalybeate waters will be found to agree best.

Iodine is universally believed to promote the absorption of the chronic inflammatory products which so commonly form in scrofulous affections. The preparation usually employed is the iodide of potassium. In order that this may produce its full effects, it should be given as freely as the patient will bear it, continued for a considerable length of time, and especially administered in combinations with other preparations of potash. With the view of preventing it from irritating the stomach, it should be given in a considerable quantity of some bland fluid. Its combination with the other salts often renders it more efficacious. For this purpose I have found the following form extremely useful for adults, the dose being proportionately diminished in the case of children:—℞ Potassii iodidi, Potassæ chloratis, āā ʒj; Potassæ bicarbonatis, ʒiij. Divide into twelve powders, of which one is to be taken night and morning in half a pint of warm milk. In other cases, the liquor potassæ, Brandish's alkaline solution, or lime-water given freely in milk, are serviceable; but I prefer the above prescription.

Cod-liver oil, which may be looked upon rather as an article of diet than as a medicine, is of essential utility in improving the nutrition of the body in cachectic and emaciated states of the system, more particularly in growing children, or in individuals who are suffering from the wasting effects of chronic suppuration; it not only fattens but strengthens the system, increasing decidedly the muscular power and the quantity of red corpuscles in the blood. It may often very advantageously be administered in combination with the iodides of potassium or iron, and given after meals.

Of the other tonic remedies which may be employed in this affection, such

as the preparations of *bark* and of *sarsaparilla*, I need say nothing further than that they may often be usefully administered in fulfilling ordinary therapeutic indications. Ringer recommends the *sulphide of calcium* as extremely valuable in scrofulous and tuberculous glands, and in chronic strumous sores and abscesses. He uses it in a solution which has much the strength of Harrogate Waters. Thus, he directs a grain of the sulphide of calcium to be dissolved in a half pint of water, and of this a teaspoonful is taken every hour. As this mode of administration is seldom practicable, the drug may be given in small doses from three to six times a day. The best form is in pilules containing from one quarter to half a grain. If these cannot be obtained, the finely powdered sulphide may be kept in a closely stoppered bottle, and enough just to cover the point of a pen-knife taken in a wine-glass of water. It cannot be made up in any mixture, as it rapidly decomposes in contact with water, giving off sulphuretted hydrogen. Under its influence, the glands, it is said, either return to the normal state or hasten on to suppuration, and chronic abscesses either dry up or are speedily brought forward and their contents discharged, a healthy healing sore being left.

Tuberculin.—In 1890, Robert Koch published certain results which he had obtained as the outcome of a long series of investigations made with the object of conferring immunity against inoculation with the tubercle bacillus and of arresting tuberculous disease. It will be possible here only very briefly to describe the chief steps by which Koch arrived at the discovery of a treatment of tuberculosis which, although it has so far been disappointing in practical utility, must be looked upon as a triumph of experimental research. If a guinea-pig be inoculated subcutaneously with a pure cultivation of the bacillus tuberculosis, a hard nodule forms at the seat of inoculation in about ten or fourteen days; this caseates, softens, and forms an ulcer which does not heal. If in such a guinea-pig a second inoculation be made about six weeks after the first, when tuberculosis is fully developed, the local phenomena are different; in a few days a small slough forms and separates, leaving a sore which quickly heals, without infecting the lymphatic glands. Koch next found that inoculation of a pure cultivation, in which the bacilli themselves had been destroyed by prolonged cold or heat, acted in a similar manner. Pure cultivations killed in this way caused little or no general disturbance in healthy guinea-pigs, but only local suppurations. Tuberculous guinea-pigs were, however, killed by very small quantities; whilst, on the other hand, if extremely minute quantities were used, the ulcers at the primary seat of inoculation could be made to heal, the glands to diminish in size, and the disease, if not too far advanced, to become arrested. The next step in the series of experiments consisted in completely separating the dead bacilli from the cultivation, and thus preventing the suppuration which was otherwise produced at the seat of inoculation. Finally, Koch found that the active principle, whatever be its nature, by which these effects are produced could be obtained by making a glycerine extract of pure cultivations of the bacillus. The glycerine extract, which is known as "tuberculin," is a brownish, slightly viscid fluid which contains about one per cent. of the active principle; it is usually diluted with 100 parts of distilled water, to which a ½ per cent. of phenol is added to preserve the fluid. The injections are made beneath the skin of the back by means of a modified Pravaz's hypodermic syringe, which is best rendered aseptic by absolute alcohol. In a healthy adult, or one free from tuberculous disease, the injection of 0·01 cubic centimetre (1 c.c. of the

diluted solution) causes slight pains in the limbs and transient fatigue, with occasionally a slight elevation of temperature. The same dose administered to an adult suffering from any tuberculous disease causes a marked general and local reaction. The general reaction, which usually begins four or five hours after the injection, consists usually of a rigor with a rapid rise of temperature, sometimes reaching 105°—106° F., with pain in the limbs, coughing, great fatigue and often vomiting. The local reaction, which has been most closely studied in cases of lupus, consists in swelling and redness of the affected area, with serous exudation which dries, forming scabs; the neighbouring lymphatic glands often become swollen and tender. These changes, which only affect the living tuberculous tissue, slowly subside, and repeated injections are usually required before the tuberculous tissue is destroyed and no further local reaction is produced. The first dose should be small, such as 0·006 c.c., and the strength may be gradually increased to the maximum (0·01 c.c.); the dose must also be regulated according to the probable amount of tuberculous tissue and its situation. As to the probable mode of action of tuberculin, one fact alone seems certain—that it destroys the living tuberculous tissue and not the tubercle bacilli themselves. It has been suggested by Koch that the fluid contains some extremely irritating substance, which, added to that already produced by the bacilli in the diseased tissues, is sufficient to cause their destruction by a process of coagulation necrosis. The eagerness with which this remedy has been put to the test in every form of tuberculous tissue is altogether without parallel in the history of medical science, but it must be allowed that the experience thus gained does not lead us to hope that the remedy in its present form is likely to be of more than very limited utility. As a means of diagnosis tuberculin may be of service in cases the tuberculous nature of which is suspected; the question being decided by the occurrence of reaction if tubercle be present.

Watson Cheyne has especially studied the effects of the treatment in surgical cases. In the treatment of tuberculous diseases of bones and joints he thinks tuberculin may be of use after operation as a means of aiding the prompt healing of the wound, whilst it may enable the Surgeon to perform less severe and radical operations than he might otherwise do. The best results have been obtained in severe cases of lupus by combining tuberculin with other methods of treatment. Lastly, it may be mentioned that William Hunter has separated three active ingredients from tuberculin—albumoses, alkaloidal substances, and extractives. Hunter has further shown that it is possible by dialysis to separate the albumoses, which exert the remedial action, from the non-albuminous bodies, which possess the fever-producing properties.

It is interesting to note that Liebreich has recorded certain beneficial results in tuberculous cases by the injection of a salt of cantharidin, the active principle of cantharides. In the small doses employed marked serous exudation occurred in the tuberculous tissue, but not from the capillaries of healthy tissues.

The **Local Treatment** of scrofulous affections is generally that of chronic inflammation (p. 229 *et seq.*). Should chronic suppuration occur it must be treated as already described (p. 263). Chronic thickenings left after scrofulous inflammations may be removed by means of lotions containing the iodide of potassium, or the carbonate of potash, applied by means of lint covered with oiled silk; a drachm of each of the salts, with an ounce of spirits of wine to eleven ounces of water, makes an excellent application, which appears often to

be very efficacious. In many cases, frictions with the iodide of lead ointment, or pressure by means of strapping and bandages, will be found the most serviceable means that the Surgeon can adopt.

In the treatment of local tuberculous disease it should be borne in mind that no external application can have any direct influence upon the bacillus. If the organism is to be destroyed it must be by the living cells surrounding it. It is all important, therefore, to remove every possible source of accessory irritation to the affected part. It should be put at perfect rest, protected from external injury and from cold. If the process is very chronic, counter-irritation may probably be of use in external diseases by causing an afflux of blood to the part. Painting with iodine may occasionally be useful in the same way. Under this treatment a large proportion of tuberculous diseases of bones and joints will undergo spontaneous cure by the processes already described (p. 1090). If, in spite of this treatment, the disease continues to advance, the morbid growth should be removed as early and as completely as possible ; thus a joint may be excised, or its synovial membrane dissected away, a carious bone scraped, gouged or removed, or a diseased testicle taken away by castration. One object in this is, by removing the local centre, to diminish the risk of general infection. If the disease cannot be removed, as is often the case in lymphatic glands, the caseous mass should be exposed and scraped away as thoroughly as possible with a sharp spoon. The cavity left may often with advantage be forcibly scrubbed with a sponge moistened with some powerful antiseptic. Even if every trace of the disease be not removed, recovery often follows the operation. Every operation on tuberculous tissues should be performed with the strictest antiseptic precautions, as there is every reason to believe that the presence of septic organisms and their products favours rather than hinders the further growth and invasion of the tubercle bacillus. In the treatment of tuberculous ulceration or abscesses, iodoform has been said to exert a specific curative influence, but this is not definitively proved. It cannot be denied, however, that its free use in the wound and externally is attended with very satisfactory results.

The hypodermic injection of carbolic acid, perchloride of mercury, emulsion of iodoform and iodine, has been tried in various forms of local tuberculosis, but not with any uniform success.

The further details of treatment of local tuberculous diseases will be given with the affections of special systems and organs.

Operations in Scrofulous and Tuberculous Cases.—In cases of tuberculous diseases of bones and joints, if the disease is chronic and advancing very slowly, operative interference may be delayed till the effects of simpler measures have been tried. In young children especially we find that very extensive disease may be recovered from under proper constitutional and local treatment without operative interference. If the disease is actively spreading in spite of rest and milder means operative measures become necessary, and with proper antiseptic precautions there need be no fear of unhealthy suppuration occurring in the neighbourhood of the disease. Infection of the operation wound with tubercle is not a common complication, but occasionally a lupoid condition of the scar is met with. After excision of the elbow, the knee, or the bones of the foot and wrist, the disease will sometimes return in the contiguous soft parts to such an extent as to render a second operation necessary ; the tissues in the neighbourhood of the cicatrix becoming swollen,

spongy, and infiltrated with a quantity of gelatinous semi-transparent granulation tissue, running into unhealthy suppuration, with fistulous tracts leading through it that cannot be brought to heal. If the disease be but partially removed, local recurrence is naturally not uncommon.

If the patient is suffering from pulmonary phthisis as well as local tuberculous disease of a bone or joint an operation should not be undertaken if it can be avoided, but even in advanced phthisis the patient may survive an amputation for a diseased joint, and even be benefited by it if he previously were suffering much from pain and discharge. If the patient is being exhausted by prolonged suppuration from a tuberculous bone or joint, removal of the source of the mischief, if possible, is the only chance of relief.

ACTINOMYCOSIS.

Actinomycosis is a chronic infective disease caused by the invasion of the tissues by a microscopic fungus to which the name of *actinomyces* or *ray fungus* has been given. It was first recognised as a specific disease in cattle by Bollinger in 1877, and in the same year Israel first described its occurrence in man. It was further investigated in 1879 by Ponfick, and subsequently by Moosbrugger, Boström, Crookshank, M'Fadyean and many others.

Pathology.—The disease is characterised both in animals and in man by the formation of tumour-like masses of granulation tissue invading the tissues in which they lie. The fungus can be seen with the naked eye as small yellowish bodies about the size of hemp-seeds, scattered through the granulation tissue. It is the presence of this fungus that sets up the inflammation and causes the formation of the granulation tissue; the large tumour-like masses being formed by the coalescence of numbers of small nodules. In some of these nodules a zone of epithelioid or giant cells may be seen surrounding the fungus, and in others a varying amount of fibrous tissue may be found apparently developed in the granulation tissue furthest removed from the fungus; the changes, indeed, closely resembling those produced by the growth of the tubercle bacillus. After a time, varying from a few weeks to a few months, the granulation tissue round the fungus softens and breaks down into pus. According to Moosbrugger, this occurs only when the diseased tissue becomes infected with the micrococci of suppuration. The abscess thus formed reaches the surface and discharges pus in which the yellow bodies above mentioned can be recognised. As the disease advances new masses of granulation tissue spring up in the neighbourhood of the first, apparently by invasion through the lymphatics.

If one of the small yellow bodies found in the pus or granulation tissue be subjected to microscopic examination, it will be found to consist of a central mass of interwoven threads, and an outer part made up of club-shaped bodies radiating from the centre, giving the whole the appearance of a rosette. In the cases of actinomycosis recorded in man, the club-shaped bodies have usually been little developed: there is, however, every reason for supposing that the fungus is identical with that found in cattle. Opinions differ as to the true significance of the clubs, and accordingly as to the real nature of the fungus. According to the older view, which is also supported by the more recent researches of Crookshank, the clubs are reproductive bodies in which spores are formed, the general plan of the fungus being, indeed, that of the higher mould fungi. Boström, however, regards the clubs as evidence of

degeneration and the result of thickening of the outer sheath by which the threads are surrounded. If this view be correct, as indeed seems probable, the organism is more correctly classed with the Schizomycetes or fission fungi.

Boström was the first observer who succeeded in cultivating the organism on artificial culture media, and it is interesting that he used the central network of the fungus and not the clubs, from which to obtain his cultivations. Nutrient agar-agar, blood-serum, and white of egg have been successfully used as culture media, and the disease has been reproduced in calves and rabbits by inoculation with the pure cultivation of the fungus obtained from a case of actinomycosis in man.

Although the disease is common in cattle there is little evidence from recorded cases in man to show that infection occurs directly from them. There is, however, some reason for believing that cereals, and more especially barley, form the usual habitat of the fungus outside the body, and it seems likely that this may be the source from which infection usually occurs.

The mode of entrance of the actinomyces into the body is variable; it probably occurs usually through some breach of continuity of the mucous membrane of the gum or mouth, or by some diseased point such as a carious tooth, or possibly, in some cases, an inflamed tonsil. More rarely, infection occurs through the respiratory tract, or through accidental wounds.

Symptoms in Animals.—In cattle the disease most commonly manifests itself as a local affection of the jaws or tongue. In the lower jaw it attacks first the cancellous tissue, destroying the bone, and reaching the surface in such a way that it was formerly mistaken for some form of sarcoma; this form of the disease is popularly known as a "wen" or "osteo-sarcoma." The affection of the tongue has received the name "wooden tongue;" whilst the so-called "scirrhous cord" in the ox or horse may be the result of inoculation of the spermatic cord at the time of castration. Generalization of the disease may occur.

Symptoms in Man.—The cases that come under the care of the Surgeon commence most commonly as a hard swelling, often painless, attached either to the lower jaw or near it in the submaxillary region. The tumour slowly increases and new centres may appear near it. After some weeks or months it becomes adherent to the skin, softens and bursts, discharging unhealthy curdy pus, in which the yellowish fungoid masses may be recognised. A sinus is then left leading to an unhealthy cavity. When it commences in the upper jaw the sinuses may perforate the cheek. If it spreads backwards towards the spine and pharynx a deep prevertebral abscess may form which may reach down to the mediastinum, and openings may form at the side of the neck leading to deep sinuses. There may be severe fever after the abscesses have opened. The disease has been known to invade the spine, causing caries of the vertebræ.

Other forms of actinomycosis in man have been recorded. Thus in several cases the lung or pleura has been primarily affected, the disease sometimes coming to the surface through the chest-wall, and in other instances extending through the diaphragm into the liver. In a case under the care of Douglas Powell and Godlee at the Brompton Hospital, the disease presented the physical signs and symptoms of an empyema. Exploration, however, showed that the right pleura contained a degenerated semi-solid material containing the

ray fungus in abundance. The boy, who was nine years of age, died after about nine months' illness. At the *post-mortem* examination the most extensive disease was found in the right pleura, from which it had extended through the diaphragm. The right lung was extensively diseased; the left contained scattered nodules, varying in size and having, on section, the "characteristic canary-coloured appearance."

Actinomycosis may occur primarily in the abdominal viscera: thus in at least two cases the first symptoms were those of perityphlitis. In one of these, recorded by W. H. Ransom, it seems probable that the disease began in the vermiform appendix; the case terminated fatally, and in addition to extensive disease in the region of the cæcum, there was a large secondary deposit in the liver. W. B. Ransom was able to diagnose a case by the detection of the spherules of actinomyces in the urine and in the fæces; here it was thought probable that the primary deposit was in the anterior wall of the rectum, and that the prostate and prostatic urethra were secondarily involved. The liver also may be the seat of the primary deposit, and in cases in which the disease becomes generalised, secondary foci may be found in the brain, kidneys, subcutaneous tissue, and other parts.

Diagnosis.—The chief interest of this rare disease to the practical Surgeon consists in the fact that clinically it may closely resemble other more common affections. Thus actinomycosis occurring in the neighbourhood of the jaws may closely simulate a sarcomatous or other malignant growth, or possibly a breaking down syphilitic gumma. We have already seen how, in the chest, the disease may be mistaken for an empyema, whilst the resemblance in its course to a new growth or tuberculous affection of the lung may be very close. Actinomycosis occurring in the abdominal viscera is likely to be confounded with different varieties of new growth and other causes of chronic suppuration. The remarkable tendency of the disease to spread beyond the limits of the organ or structure in which it commences, as, for instance, from the lung through the diaphragm into the liver, has been especially insisted upon by several observers. The only certain means of diagnosis consists in the detection of the fungus with the naked eye or microscope in the discharges or other material obtained from the seat of disease. The careful routine examination of these in all doubtful cases will indeed often materially assist the Surgeon in arriving at a correct opinion.

Treatment.—If the disease is superficial, as when it commences in or near the lower jaw, the tumour must be freely incised, and the unhealthy granulation tissue scraped away with a sharp spoon. This operation is often successful in effecting a cure. In cases of deep-seated disease no surgical interference is likely to be indicated until the disease has gradually worked its way to the surface; free incision, with scraping and drainage, should then be resorted to. The administration of iodide of potassium in full doses has been thought to be beneficial.

CHAPTER XXXVI.

VENEREAL DISEASES.

The term *Venereal Disease* is used to denote those affections which arise primarily from sexual intercourse, viz., the Local Contagious Chancre, Syphilis, and Gonorrhœa. Hunter believed that all these arose from one poison; but the experiments of Ricord and others conclusively proved that gonorrhœal pus when inoculated never produces a chancre, and the pus of a chancre cannot cause gonorrhœa. Syphilis and the local contagious chancre, were, therefore, clearly separated from gonorrhœa; but for a considerable time these two were still included under the common name of syphilis. Ricord, however, by inoculation showed that the two diseases are not identical. The inoculation of the virus of syphilis infects the whole system, while that of the local contagious chancre is never followed by constitutional symptoms. Each of the diseases—Local Contagious Chancre, Syphilis, and Gonorrhœa—propagates itself, and no other. All these diseases may, however, co-exist in the same person. Thus, we shall have occasion to notice the coincidence, in some cases, of the local chancre with the phenomena of constitutional syphilis. Again, Ricord has pointed out, that a woman may at the same time be affected by gonorrhœa and by chancres on the uterus; and this probably explains those cases in which, after connexion with the same woman, different men have contracted different forms of disease, or even both affections.

It is impossible here to discuss the various views which were formerly held with regard to the supposed relation of the virus of the local contagious sore or soft chancre to that of true syphilis. For this I must refer the reader to special works on venereal diseases. In this chapter will be described—1, the Local Contagious Ulcer or Chancre; and 2, Syphilis; the consideration of Gonorrhœa being reserved till we speak of Diseases of the Urinary Organs.

1. LOCAL CONTAGIOUS ULCER OR CHANCRE.

The **Local Contagious Ulcer, Simple Non-infecting Sore or Soft Chancre,** is a local infective inflammation, produced by the action of a virus which increases in quantity in the affected area. The increase of the poison is supposed to take place by a process analogous to fermentation occurring in the inflammatory exudations. Thus the inoculation of an infinitesimal dose of the poison may result in the formation of a sore from which many drachms of infective pus may be discharged before the process ceases. The intensity of the local action of the poison is such as to cause a progressive destruction of the tissues by ulceration. As a rule it shows but little tendency to diffuse itself amongst the tissues, the area of inflammation beneath and around the ulcerating surface being usually very limited. Occasionally, however, from

causes which are not fully understood, the intensity of the virus is greater: it then extends more deeply, causing more rapid destruction, the dead tissues not being removed by ulceration, but remaining as an adherent pulpy slough. This form is described as the phagedænic or sloughing chancre. The virus of a simple chancre may be taken up by the lymphatics and carried to the nearest lymphatic glands, where it may set up an inflammation of the same character as that at the primary seat of disease. Beyond this it never goes, and although we must suppose that it is possible that it may enter the blood-stream, it certainly produces no general infection under any circumstances. Of the exact nature of the virus we know but little. Chancrous pus is said to lose its activity after drying, or after being kept for some time in capillary tubes. Its infectivity is readily destroyed by alcohol, corrosive sublimate, and many other chemical substances. No specific organism has as yet been shown to be constantly present in the discharges from a chancre.

Ricord and numerous other observers have shown clearly by experiment that pus from a chancre, during its first period, if inoculated into any part of the surface of the body, will produce a specific sore of the same character. After the inoculation has been repeated a certain number of times the individual seems to become insusceptible to the poison, and no chancre follows the introduction of the pus. Boeck states that this occurs usually after three or four months of repeated inoculation, but the time varies in different individuals; some never acquire an immunity, and in all it is only temporary. No pus that is not chancrous can occasion the specific venereal ulcer.

Whatever the appearances presented by a chancre, there can no longer be any doubt that the disease arises from one kind of virus only: the modifications in the sore depending on its situation, on the constitution of the patient, and occasionally on that of the individual who communicates the infection. That this is so, is evident from the facts that every chancre, when inoculated, reverts to one typical form; and that, however much chancres may ultimately differ, they all present the same characters during their early stages.

Origin and Progress.—A chancre is necessarily contracted in most cases during sexual intercourse with a person already contaminated by the disease. It is almost invariably met with on the genital organs, being much more rare on other parts, such as the fingers or face, than the primary sore of syphilis. The reason of this is that in the simple chancre the discharge from the sore is the only source of infection, while in syphilis, the secretions from the mouth, the discharges from secondary syphilitic sores, and even the blood, possess infective properties. In some cases, the disorder is contracted from the contact of filthy clothes or dirty utensils with the person; and not uncommonly, it is said, chancres are contracted in public water-closets. Although the latter mode of infection is not impossible, it should be received with doubt, as it is an explanation not uncommonly adopted by those who desire to account for the consequences of an act of immorality, in a way that does not expose them to reproof. In speaking of the mode of propagation of syphilis, Wiseman says: "It is frequent to mention other secondary ways of the propagation of it; as lying in the same bed with an infected person, lying in the same sheets after them, or wearing their cloaths. . . . . Drinking with one so diseased, or sitting on the close-stool after them, are likewise numbered among the causes of infection. These are all such convenient excuses for the more shie and coy patients, who will not otherwise be brought to confess their

distempers, that it is pity to discountenance them" (Wiseman: "Several Chirurgical Treatises. Of Lues Venerea," London, 1676).

The soft chancre usually commences with a small excoriation, which appears to have been directly inoculated with the specific poison. In other cases, though more rarely, it may be seen at first in the shape of a small vesicle or pustule, which speedily breaks, leaving an ulcer of a specific character in its site. Very generally, however, this pustule escapes observation, and the disease is presented in the first instance as an ulcer. The chancrous ulcer seldom makes its appearance until three to five days after connexion. In some cases, however, I have observed it, evidently from the infection of a fissure or crack, on the day following impure intercourse; and in rare instances, its appearance may be delayed a few days longer than the time which has been mentioned.

The progress of a chancre that has been artificially inoculated on any part of the cutaneous surface is as follows, and its study will serve to elucidate what takes place in other circumstances. During the first twenty-four hours after the introduction of the specific pus into the skin on the point of a lancet, we find that some inflammation is set up around the puncture, which becomes hot, red, and itchy. About the third or fourth day, a pointed pustule is produced, which is at first deep-set, but becomes on the following day more superficial, with some depression in the centre, resembling rather closely a small-pox pustule. On the fifth day the pustule bursts; and on the sixth it has usually dried, forming a small round scab, which comes off, leaving an ulcer which presents the typical characters of a true chancre, being circular and depressed, with an irregular "worm-eaten" surface of a foul greyish colour, which cannot be cleansed, sharp-cut edges, a base slightly indurated by inflammation, and an angry-looking red areola around it. Such induration as may be present is not sharply defined, but fades away into the surrounding healthy tissues. This is the typical chancre, and these are the appearances that every true venereal non-syphilitic sore on the skin will present about the fifth or sixth day after inoculation; from this time it may diverge more or less completely from these characters, but will yet, if inoculated at any time during the poisonous stage, produce an ulcer that will run the specific course up to the same period, after which it may in its turn again deviate into one or other of the unusual forms that chancres occasionally assume.

VARIETIES.—These have been described under various denominations by the numerous writers on these affections. The following classification will include them all: —1, the Simple or Soft Chancre, or Chancrous Excoriation; 2, the Sloughing Chancre; and 3, the Phagedænic Chancre. The particular form of the sore is in each case determined by its situation, and the constitution of the patient or that of the individual furnishing the contagion.

1. **Simple or Soft Chancre,** or **Chancrous Excoriation,** is the most common form of the disease. It consists of one or more small sores, somewhat circular in shape, of a very shallow character, resembling rather an abrasion, with sharp-cut edges, sometimes slightly undermined, and having an irregular, spongy surface, of a tawny greyish or yellowish colour, with a narrow red areola around the edge; it is in many cases attended with much heat and itching. These sores are usually seated on the cleft under the corona glandis, or about the glans, the whole of which may be studded with them. In fact, one peculiarity of this chancre is its tendency to multiplication on the con-

tiguous structures. In other cases, the sores invade the frænum, which may be perforated; or they may occupy the mucous surface of the prepuce. The absence of induration is a marked feature of these sores; the only exception being that the base of an inflamed sore, especially on the frænum, may be slightly hardened.

The excoriated chancres not unfrequently present somewhat varying appearances. In some cases their surface becomes covered with large fungous granulations; hence these are termed *fungating sores*. In other instances they are very irritable, becoming exceedingly sensitive, with a tendency to spread, and having a dusky red areola around them. These chancres are very frequently attended by much general inflammation of the penis; the organ being red and swollen from subcutaneous œdema, and usually in a state of phimosis, with much purulent discharge from between the prepuce and the glans.

2. **Sloughing Chancre.**—This may be looked upon as a gangrenous inflammation of a non-infecting sore. It is usually the result of want of cleanliness, and of the confinement of the specific pus under a long foreskin. It is most likely to occur in weak and debilitated subjects, but it is also met with in healthy young men. The penis becomes red, greatly swollen, and somewhat brawny, the prepuce cannot be retracted, and very offensive pus, often stained with blood, escapes from beneath it. If it be not relieved, a dusky spot soon makes its appearance on one side of the prepuce; this rapidly extends, thick black pultaceous sloughs appear, and thus one side of the foreskin may be destroyed, or a round aperture may form in it, through which the glans projects, whilst the swollen and inflamed extremity of the prepuce hangs down behind it, giving the organ a very remarkable, and, at first sight, somewhat puzzling appearance. As soon as the pent-up discharges find exit in this way, the intensity of the inflammation is somewhat relieved. In other cases the whole foreskin may slough, and the glans be deeply implicated, and even the corpora cavernosa denuded. Severe hæmorrhage from the dorsal artery or the artery of the frænum may take place. Not uncommonly the pus, being unable to find exit from the orifice of the swollen prepuce, bursts through the reflection of the foreskin at the corona, and burrows beneath the skin of the penis for some distance superficial to the corpora cavernosa. I have seen it extending in this way for a distance equal to the two first joints of the finger. In other cases, abscesses may form on the penis along the line of the dorsal lymphatics. Lastly, when the sore is near the frænum, it may perforate the urethra, leaving a fistulous opening which it may be impossible to close. After the separation of the sloughs, healthy granulations spring up, the sore loses its specific character, and cicatrization advances rapidly.

3. The **Phagedænic Chancre.**—This differs from the sloughing chancre in not being evidently due to want of cleanliness. It attacks sores that can be freely exposed, as well as those that are concealed beneath a long foreskin, and if occurring in the latter condition does not show the same tendency to cease extending as soon as the retention of the discharges and inflammatory tension are relieved by slitting up the foreskin. The sore may assume the phagedænic character from the very first, or this may be set up at some period of its course. Phagedæna affects both the simple chancre and the true syphilitic sore. In fact some Surgeons, especially Jonathan Hutchinson, believe that it is invariably syphilitic, either attacking a primary syphilitic sore or a

soft sore in a person already suffering from syphilis, and Berkeley Hill states that a considerable proportion of cases are followed by secondary symptoms. As soon as the phagedænic ulceration sets in, the characteristic appearances of the sore are lost, so that it is not possible to say what form it had originally assumed.

The phagedænic chancre is characterized by a tendency to erosion, with extensive destruction of the parts that it invades. The progress of the sore varies greatly in its rapidity. In some cases it advances slowly and irregularly, healing at one part while spreading at another; thus forming the *serpiginous sore.* In other cases the advance is extremely rapid. In men the whole thickness of the penis may be destroyed for some distance, and in women the recto-vaginal septum may be perforated. Between these forms every variety may be met with. Wallace has divided phagedænic sores into three varieties: those *without slough*, those *with white slough*, and those *with black slough.* This classification appears to me to be a useful and practical one.

The *phagedænic chancre without slough* is a truly eroding ulcer, spreading with sharply-cut edges, attended with slight inflammation, and with moderate activity of progress; it is commonly observed about the frænum and under part of the glans, and very frequently hollows out and destroys the organ in this situation to a considerable extent. When reaching the skin, it often assumes the serpiginous form.

In the *phagedænic chancre with white slough*, we find an irregular eroding ulcer, with a thin margin of white slough situated at the junction of the dead and living structures; that which covers the surface of the sore having usually become darkened by exposure to air, to dressings, and to secretions.

The *phagedænic chancre with black slough* differs but little from the last, except in the colour of the slough, which may be in a great measure accidental, and in its tendency to somewhat rapid extension.

Phagedænic sores are most commonly met with in persons suffering from debility from want of food, or after exhausting diseases, and in scrofulous subjects. Chronic Bright's disease and chronic alcoholism may also be mentioned as predisposing causes. Chancres are also very apt to assume this form amongst troops exhausted by the hardships of a campaign. Phagedænic sores when spreading rapidly are often accompanied by much pain and constitutional disturbance.

SITUATION.—As simple chancres almost invariably result from connexion with persons suffering from sores of similar nature, they commonly occur on the genital organs. Berkeley Hill states that 99 per cent. are in this situation. Accidental inoculations on the fingers of medical men or on the face are extremely rare, in fact almost unknown. On the genital organs in the **male** they may be met with in various situations. They are by far most commonly seated in the angle formed between the glans and the prepuce; the situation next in order of frequency is the orifice or the inner surface of the prepuce, next the frænum, then the glans, more rarely the orifice of the urethra in some cases extending a short way down the canal, and lastly the skin of the body of the penis. Those about the frænum are often sloughy and irritable, have a great tendency to perforate or destroy this membrane, and are more frequently followed by hæmorrhage or bubo than any of the other varieties of the disease.

In **women,** chancres are most commonly situated on the external organs of generation, usually just inside the fourchette or labia minora, very rarely indeed on the lining membrane of the vagina, but sometimes on the cervix or os uteri; hence it is impossible ever to pronounce a woman free from chancre without examining these parts by means of the speculum. When situated upon the external organs, they are not unfrequently concealed between the rugæ of the mucous membrane. In these cases, their presence may sometimes be detected by the labia being swollen and œdematous from the irritation they produce; œdema of one labium only is especially suggestive of the existence of a sore.

Chancres may also form on other parts where they have been accidentally or purposely inoculated. Thus in 1839 I saw in Ricord's wards, a man, labouring under *eczema of the legs*, in whom the cutaneous disease had been converted into a series of immense chancres by accidental inoculation from a sore on the penis.

Diagnosis.—The diagnosis of chancre is usually not difficult, the peculiar character of the sore enabling the Surgeon to recognize it in all its forms. In some instances, however, it is by no means easy to say positively whether an ulcer on the penis be chancrous or not. It is especially difficult to distinguish some forms of excoriated chancre from herpes on the prepuce or glans, or from those slight excoriations that many men habitually contract after a somewhat impure connexion; so, also, the wound resulting from a ruptured frænum often presents a suspicious appearance.

Herpes of the prepuce is recognized by the closely-set crop of small vesicles with some redness round them. Herpes may become inoculated with the poison of a chancre. Pustules then quickly form in the place of the vesicles, and burst, leaving a number of small sores which soon coalesce. A simple excoriation, or the wound from a ruptured frænum, can only be distinguished from a chancre by watching the sore for a few days; it is better, however, not to wait till the characteristic appearances show themselves, but to treat every doubtful case as a soft chancre. When the prepuce is in a state of inflammatory phimosis, it is always extremely difficult to determine without slitting up the foreskin whether there be chancres under it, or whether the discharge be due to simple balano-posthitis or gonorrhœa. Sometimes, however, the inflammatory induration round the sores can be felt through the swollen foreskin. The diagnosis of the simple non-infecting chancre from the primary syphilitic sore will be described with the latter affection.

Treatment of Non-infecting or Soft Chancres.—Until the simple non-infecting chancre was clearly distinguished from the true syphilitic sore much difference of opinion and practice prevailed. It is now, however, fully recognized that the simple chancre, being a local disease, and occurring in the great majority of cases in persons otherwise in perfect health, requires no special constitutional treatment. The gangrenous and phagedænic forms, on the other hand, being often accompanied by serious constitutional disturbance, or depending partly on a debilitated state of health, require constitutional treatment as well as local.

Local Treatment.—This has for its object the destruction of the specific character of the sore.

With a view of modifying the specific character of the sore, there is no application so efficacious as *iodoform*. It will usually cure a simple soft

chancre in a week or ten days. The crystalline, and not the precipitated, iodoform should be used, as the latter sometimes causes irritation. It is applied by simply dusting a small quantity of the powder on the sore twice a day, and afterwards covering it with a piece of cotton-wool, either simple or impregnated with iodoform. At each dressing the sore must be carefully washed with tepid water. The only objection to this treatment is the powerful smell of the drug. If the pure iodoform is used, it is better to apply it before dressing in the morning and after undressing at night, to avoid any chance of its falling upon the clothes. Berkeley Hill recommended the use of "iodo-carbon paste," composed of iodoform in fine powder, ʒj; wood charcoal, ʒij; glycerine of starch, ʒij; glycerine, ʒj; oil of lavender, ℳxx; or a solution of iodoform in eucalyptus oil: iodoform, ʒiss; oil of eucalyptus, ℥j; olive oil, ℥v. The smell of iodoform may also be lessened by the addition of coumarine, obtained from the Tonquin bean in the proportion of 1 in 50, or of finely-ground coffee 1 in 3. Iodol, which has no unpleasant smell, may be used instead of iodoform, but it is very expensive; it should be lightly dusted over the sore, and then a piece of thin lint soaked in lead lotion applied. If however the odour of iodoform is not a very great objection, there is nothing so efficient as the pure crystals.

The treatment of simple soft sores with strong caustics is not to be recommended. In some cases, however, in which the sore begins to spread rapidly, with a tendency to become phagedænic, Ricord's paste may be very useful. This consists of sulphuric acid and powdered charcoal mixed so as to form a thick paste. The sore should be washed and a layer of the paste applied with a match. The serous discharge should be absorbed by a dry wool dressing, and on about the third day the slough will usually separate in a hot bath, a healthy surface being left. This treatment is, however, very rarely required.

If the healing sore be weak and fungating, an astringent lotion, such as the following, will be found most useful: ℞ Tannin, gr. xx; Tinct. lavandulæ comp. ʒij; Vini rubri, ℥iv. Or a solution of sulphate of copper may be applied, and the sore touched from time to time with nitrate of silver.

In using lotions to any form of chancre, care should always be taken to keep a piece of lint soaked in the fluid constantly applied between the prepuce and the glans, and, in women, between the labia; for, unless this be done, the contact of the inflamed mucous surfaces with one another will tend to keep up the ulceration.

These are the means that are generally most useful in *Simple Chancres*. In some cases, however, inflammation of the sore, or peculiarities in its situation, demand modifications of the treatment.

If there be much inflammation about the sore and the prepuce, this must first be subdued by the application of wet dressing, or of lead and spirit lotion. When this is removed, if the sore have not lost its specific character, iodoform should be applied in the usual way.

Should there be phimosis with discharge of pus from under the tightened prepuce, this must be slit up, so as to expose the subjacent chancres. It is better at the same time to complete the operation of circumcision by removing the foreskin with the knife or scissors after it has been slit up along its dorsal aspect. Otherwise when it heals an inconvenient pendulous flap of skin will be left, requiring subsequent removal. In order to avoid infection of the raw surface from the chancre, the operation may be thus performed. The fore-

skin is first slit up along its dorsum ; the surface of the glans and the prepuce are then thoroughly cleaned with carbolic lotion (1 in 20), and the sores wiped out with chloride of zinc solution (40 grs. to ℥j). The surface of the sore may be rubbed forcibly with a dossil of lint soaked in this solution, to remove any adherent slough. Everything being thus thoroughly cleaned the circumcision may be completed ; after ligaturing any bleeding vessels, the parts must be thoroughly sprinkled with iodoform and wrapped in iodoform wool. By these means infection of the wound can generally be avoided. There should be no delay in performing the operation. When pus comes from under a long foreskin and its source cannot be seen the patient should always be advised to submit to circumcision, unless there is some very marked improvement, following the application of fomentations and the injection of antiseptic solutions, by the third day at the latest. If the pus is offensive the operation should be performed at once, as it probably arises from a sloughing chancre.

If the chancres be situated round the orifice of an elongated and tight prepuce, circumcision is the best means of removing the disease and the inconvenience at the same time. The precautions just described must be adopted to prevent infection of the cut surface.

In the **Sloughing Chancre**, when the prepuce is greatly swollen, in a state of inflammatory phimosis, and of a deep red or purplish colour, with threatening of extensive gangrene, a director should be passed between it and the glans penis, and the swollen prepuce slit up. In this way tension is removed, and the sloughing arrested. The chancre when exposed will be found to be covered with a pulpy grey tenacious slough. This is best removed by forcibly rubbing the surface with a piece of sponge or lint soaked in a solution of chloride of zinc (gr. 40 to ℥j), after which iodoform must be applied. The application of nitric acid is seldom necessary. If the state of the parts is such as to admit of it, the operation of circumcision may be at once completed. If there be much sloughing of the prepuce it is better to delay the completion of the operation till the sloughs have separated, when perhaps it may be found unnecessary. During the separation of the sloughs the penis should be wrapped in lint soaked in some warm antiseptic solution, as boric acid or permanganate of potash. The patient should sit in a hot hip-bath (98° F.), to which some solution of permanganate of potash (Condy's fluid), or some boric acid, may be added, for half an hour or more twice a day. A little hæmorrhage need cause no anxiety, and is usually easily arrested by dry cotton-wool and pressure, but if it be profuse, the patient should be put under chloroform, and the actual cautery freely applied. This not only stops the bleeding, but arrests the progress of the sloughing. When once the chancre is healthily granulating, it must be dressed in the same way as any common ulcer.

The local treatment of the **Phagedænic Chancre** depends on the form it assumes. If it be the eroding ulcer without slough, iodoform will often arrest it, but its action is by no means certain. If it fails, perchloride of mercury (gr. ij to ℥j), diluted if it is too painful, is often of great service. Should this fail, the strong nitric acid may be applied, after which it may be dressed with a dilute nitric acid and opium lotion. If the phagedænic process be spreading rapidly with a white or black slough, the sore must be treated like hospital gangrene. The slough must be scraped away, and fuming nitric acid, or in

bad cases the actual cautery, applied freely, after which iodoform and boric acid fomentations, or lint soaked in the nitric acid and opium lotion, may be used, the caustic being applied again whenever there is any tendency to extension of the disease. In obstinate cases of phagedænic chancre Hebra in Germany and Hutchinson in this country have recommended that the patient should be immersed for ten hours daily in a bath of hot water, maintained constantly at a temperature of 98° F. The bath must be repeated daily till healing is distinctly taking place.

Constitutional Treatment.—The **Simple, Soft,** or **Excoriated** sore requires no constitutional treatment beyond attention to the ordinary rules of health.

In the **Sloughing Chancre** it frequently happens that the mischief is entirely due to local causes, such as the accumulation of discharge under a long foreskin. In these cases the constitutional disturbance, which may be severe, will subside as soon as the local condition is relieved. In other cases the sloughing is due partly to local causes and partly to a depressed state of health. In these ammonia and bark, good nourishment and abundant stimulants, will be required. Opium may be necessary to relieve pain and irritability, and eventually the patient's strength may be supported by iron and quinine. In a sloughing chancre mercury is never required.

In the constitutional treatment of **Phagedænic Chancre** it must be borne in mind that the patient is usually in a debilitated condition before the invasion of the disease; consequently tonics, such as bark or iron, with good food and stimulants, are frequently required, together with opiates to allay pain and procure rest. The preparations of iron, especially the ammonio-citrate and the tartrate, either alone or in combination with sarsaparilla, are especially useful in these cases. It has before been stated that phagedænic ulceration may start from a true syphilitic sore or occur in a patient suffering from constitutional syphilis. Mercury is, however, often inadmissible, and if given indiscriminately may do much harm in many cases by further debilitating the patient. On the other hand, some sores which have resisted treatment for a long time may rapidly improve if mercury be carefully administered in small doses. Wallace stated that its beneficial effects are most marked in those cases which are characterized by the presence of a white slough. It is best given as the perchloride, in doses of $\frac{1}{32}$ to $\frac{1}{16}$ of a grain with tincture and decoction of cinchona. It is in these cases also that the local application of perchloride, in the strength of from one to two grains to the ounce of water, is so frequently useful.

Consecutive Symptoms of the Local Contagious Ulcer.—Chancres are not unfrequently followed by a series of affections which may be termed *consecutive*, depending as they do upon the primary disease, but being local in their character, and presenting no evidence of constitutional infection. These consecutive symptoms are three in number: viz., Contraction of the Cicatrix of the Chancre, Bubo, and Warts.

Contracted Cicatrices.—Most excoriated chancres are healed without any marked cicatrix being left; but, in the phagedænic and the sloughing chancres, there is always loss of substance, often to a considerable extent, and consequently a depressed scar. If the ulceration happens to have involved the orifice of the urethra a very intractable stricture may result, which may subsequently necessitate division of the scar for its relief. The situations of all venereal ulcers should be watched for some time, however readily the sore

may have healed; for the virus of syphilis may have been introduced with that of the simple chancre, and if this have happened, induration will commence at the point of contagion, when the time of incubation has elapsed. Thus a month or six weeks should pass away after the suspicious connexion, before the Surgeon pronounces the patient safe from syphilis.

Bubo.—By bubo is meant an inflammatory enlargement, frequently terminating in suppuration of the lymphatic glands which receive the lymph-stream from the inoculated surface. A bubo, though generally produced in the groin by absorption of irritating matter from chancres on the penis, may occur elsewhere—as for instance, in the axilla, in cases of chancre on the finger; in the submaxillary region, if the disease occur on the lip. The enlargements of the inguinal or other lymphatic glands that occur in cases of venereal chancre, may be either simple or specific. In the former the irritating material may be derived from concomitant inflammation about the sore, as when balano-posthitis or phimosis is present, without the specific virus of the soft chancre reaching the gland. In scrofulous subjects this readily takes place. In these cases the bubo is termed *sympathetic*, and the affection must be considered as simple inflammation. It may speedily subside without the formation of pus, but should suppuration take place the pus possesses no specific properties, and is not inoculable. It constitutes in fact a simple glandular abscess and presents nothing in any way peculiar. Indeed, in a very large proportion of cases of simple chancre, there is some slight enlargement with tenderness of the glands above Poupart's ligament, accompanied by some degree of stiffness and dragging pain. The liability to irritation and inflammation of the glands in the groin is greatly increased by the patient walking about or otherwise exerting himself. But I do not think that causes such as these influence the occurrence of the other and more troublesome affection of the lymphatic glands, namely the *virulent bubo*, which appears to originate from direct absorption of the specific poison of the chancre; so that we may consider with Ricord that a virulent bubo is, properly speaking, a chancre of a lymphatic gland, differing only in seat from that which is situated on the surface of the body. Ricord has observed, and I have often had an opportunity of testing the correctness of this observation, that the pus of a virulent bubo is as readily inoculable as that of an ordinary chancre. This kind of bubo, then, may be considered as a *specific* abscess, at first limited to the gland, but subsequently infecting the surrounding tissues. Ricord also pointed out that in some cases suppuration takes place round the affected gland without infection of the tissues by the specific pus. Thus if a virulent bubo be carefully opened a cavity is sometimes exposed in which the gland can be seen partially separated by pus from the surrounding tissues. Inoculations made with the pus surrounding the gland may fail, but if the incision be carried further into the gland itself a second cavity is found containing inoculable pus. If this condition be met with, infection may be prevented by scooping the gland out entire without opening into it. When once a gland has become virulently infected, it is probable that no treatment can prevent suppuration.

Usually only one or two glands suppurate, although several may be enlarged; and very commonly the disease is confined to one groin though *both* may be affected, more particularly if the chancre be situated on the *frænum*.

In the early stages it is impossible to distinguish a sympathetic from a virulent bubo. The glands become swollen and tender; at first they are not adherent to the skin, and their form and outline can be clearly recognized. As soon as the inflammation extends to the tissue outside the capsule, the glands become lost in the surrounding inflammatory exudation. The swelling is at first brawny and hard, but it soon becomes softer and boggy, after which distinct fluctuation becomes perceptible. The skin, at first red, becomes dusky and purple, and if the case be left to nature, it is frequently extensively undermined before the bubo bursts. If the bubo be simple, the cavity presents nothing differing from that of an ordinary abscess. If it be virulent, its walls are ragged and sloughy-looking, and instead of healing, the sore may spread, with all the characteristics of a chancre.

Bubo most commonly occurs during the second or third week after the first appearance of the chancre, but may happen at an earlier or at a later period, even after the chancre itself has healed.

A rare form of bubo is that which forms within the abdomen in the lymphatic glands in this situation. It is a very dangerous variety, and may prove fatal by rupture into the peritoneum and consequent peritonitis.

Primary Bubo.—The French Surgeons have described a form of bubo which they call *bubon d'emblée* or *primary bubo;* this is said to occur from the direct absorption of the specific poison, without the previous formation of a chancre.

Only one case apparently of this kind has fallen under my observation, but I am not yet fully convinced that this suggested mode of origin is the true one. A young man was admitted into the Hospital with a rather large abscess in the groin. He denied ever having had any venereal disease, though he admitted having had intercourse with a woman of the town. On examining the penis, no chancre, abrasion, or cicatrix could be discerned. The abscess was opened, and two ounces of rather bloody and very thick pus were let out; no enlarged glands could be seen. For the sake of experiment the pus was inoculated into the left thigh, and two distinct and well-marked pustules were produced. That such an effect can be obtained by matter of very irritating character without any venereal origin, is shown by the experiments of several Surgeons who have succeeded in inoculating matter from itch and impetigo contagiosa; hence it must not be concluded that in this case the bubo was consequent on the direct absorption of venereal matter along the lymphatics. In fact, the proof of the existence of this form of bubo is far from satisfactory. It frequently happens that small excoriated chancres heal in a few days, before which time, however, the inguinal glands have become irritated and enlarged; and, as the enlargement of the glands goes on after the healing of the chancre, a bubo may be formed when all trace of its primary source has entirely disappeared.

Creeping Bubo.—In some cases a virulent bubo, as has been well shown by Solly, assumes a tendency to creep or spread over the neighbouring integument, extending in this way a considerable distance down the thigh, upon the abdomen, or over the ilium. This *creeping bubo* is characterized by the peculiar semicircular or horse-shoe shape that the sore assumes, and by its tendency to cicatrize at one margin, whilst it slowly extends at the other; the cicatrix always being thin, blue, and weak, closely resembling that of a burn.

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After a bubo has disappeared, a good deal of induration may be left in the

glands of the groin, perhaps with matting together of the surrounding areolar tissue; and this induration may continue for years, or even for the remainder of life.

The **Treatment** of bubo consists, in the first instance, in endeavouring to prevent the occurrence of suppuration; and should pus form, in letting it out.

The *Preventive Treatment* of bubo consists in perfect rest of the part, and the application of leeches and of cold lead lotions. In reference to the application of leeches, there is a practical point that requires attention—viz., that the leech-bites may become infected by the chancrous pus, and thus converted into a number of new chancres. This accident is best guarded against by covering the bites with collodion and plaster.

If there be much pain, and if the skin be already reddened, hot fomentations, and the application of equal parts of extract of belladonna and glycerine, will offer the best chance of arresting the progress of the inflammation.

If the bubo be indolent, with but little tendency to suppuration, the application of blisters or tincture of iodine may be of service. Berkeley Hill states that steady pressure by means of a pad of cotton-wool and an elastic bandage may sometimes produce absorption. The application of lint soaked in a lead lotion containing about two drachms of the solution of the subacetate and one ounce of spirit to half a pint of water has been said to promote resolution.

If, notwithstanding our endeavours to prevent suppuration, matter form within or around the gland, as evinced by the swelling becoming soft, boggy, and inflamed, a free opening should made. This should, as a rule, be parallel to Poupart's ligament, but if a vertical incision would lay the cavity open more perfectly, there is no objection to adopting it. The incision should be made early, before the surrounding skin has been undermined and thinned. If this should have happened it may be necessary to cut it away with scissors, before healing will take place.

After the bubo has been opened it should be dressed from the bottom, either with salicylic or iodoform wool or lint soaked in carbolic oil (1 in 10), or some such simple application.

If the cavity presents a chancrous appearance, being irregular and sloughy, with elevated and angry red edges, it should be treated by the free application of iodoform in the same way as for the original sore. If on opening the bubo a gland can be seen projecting into the cavity, attached only by one side to the wall of the abscess, this is best scooped out either with the finger-nail or the handle of the scalpel, otherwise it is apt to keep up the suppuration and delay healing. Sometimes, even after the bubo has been opened, the pus may burrow in various directions. Such cases are best treated by laying open the sinuses freely to the very end with a probe-pointed bistoury.

Zeissl opens the bubo by a number of small punctures with a tenotomy knife, after which lint soaked in lead lotion (Liquor Plumb. Subacetatis, ℥ss., Rectified Spirit, ℥j, water, to O j), may be kept constantly applied. By this means he says that scarring can often be avoided.

Should sloughing or phagedænic ulceration commence in an open bubo, extensive destruction of tissue may ensue, and even fatal hæmorrhage from the femoral artery has been known to occur. The sore must be treated in the same way as the sloughing or phagedænic chancre. The application of nitric

acid is occasionally necessary. If there be any signs of syphilis the cautious administration of mercury may be required.

During the treatment of a suppurating bubo the patient should, if possible, be kept at rest till the sore is superficial. Movement greatly delays healing, and in some cases a splint is required to fix the thigh.

Venereal Warts.—Warts occur frequently round or on the scar of a chancre, independently of any constitutional affection, but merely from simple continued irritation of the muco-cutaneous surfaces. They differ in no respect from those which frequently follow gonorrhœa. They commonly occur on the prepuce or glans, and are especially apt to be situated in the angle between these parts; they are of a red colour, very vascular, and, if left without interference, may increase immensely in size and number, distending the prepuce, and giving a clubbed appearance to the penis; there is then always phimosis, and the tension of the prepuce may be such that ulceration may take place in it, allowing a protrusion of these growths through an aperture in its side. These warts are occasionally met with on the labia, forming large, irregular, cauliflower-looking masses. The *Treatment* consists in the early stage when the warts are small, in the application of salicylic collodion (p. 1033), under which they usually quickly disappear; or they may be carefully painted with the strong liquor plumbi, or with liquor sodii ethylatis. When they have reached a larger size the prepuce must be laid open unless the warts are so small that the glans can be readily exposed by drawing the foreskin back. The warts may then be pared off with scissors, and the part from which they grow touched with nitrate of silver. Even after this they are very apt to recur, especially under a long, moist foreskin. In such a case careful attention to cleanliness and the use of a powder of oxide of zinc and starch or the application of an ointment composed of vaseline, with about one-tenth part of extract of belladonna added to it, will usually cure the tendency to recurrence. If these measures fail, circumcision may be necessary. In women, warts must be treated in the same way; but if they are of great size, Paquelin's cautery or the galvano-cautery should be used in removing them, to avoid loss of blood.

II.—SYPHILIS.

Syphilis is a specific disease, or general infective process, resulting from the inoculation of a virus, which multiplies in the system till the whole body is infected. It is communicated by the direct contact of the blood, secretions, or discharges of a person suffering from syphilis with an abraded surface of a healthy individual, and under certain circumstances it is also transmitted from syphilitic parents to their offspring. It is therefore contagious, but not infectious.

The exact nature of the virus is not known. Klebs, Birch-Hirschfeld, and some others, have described a special microscopic organism of an oval form, or nearly approaching a short rod in shape, which they believe to be in some way connected with syphilis. Birch-Hirschfeld observed it in gummata, and in a flat condyloma, but failed to detect it in the blood of a patient suffering from active syphilis. Lustgarten has described a bacillus somewhat resembling that of tubercle as being constantly present in the primary and secondary lesion of syphilis, but his observations have not yet been fully confirmed. More evidence

is required before any conclusions for or against the fungoid origin of syphilis can be drawn from these observations.

Syphilis is divided into *acquired* and *hereditary or congenital*, and there is sufficient difference between these two forms to justify their being described separately.

Syphilis runs a course tolerably definite in its main phenomena, but varying in duration and detail. It is divided into various stages, which, although perhaps not capable in all cases of being sharply separated from each other, are sufficiently distinct to be used as a means of classifying the manifestations of the disease.

The *first* stage is the **period of incubation,** extending from the inoculation to the appearance of the local signs of the disease at the seat of infection.

The *second*, or **Primary Stage,** includes the appearance of the characteristic initial manifestation, the indurated sore, accompanied by indolent enlargement of the nearest group of lymphatic glands.

The *third* includes the period during which the so-called **Secondary Symptoms** make their appearance. These consist of more or less symmetrical eruptions on the skin and mucous membranes, ulceration of the tonsils, condylomata, periostitis, iritis, loss of hair, &c.

The *fourth* stage, or **Tertiary Syphilis,** includes the more remote effects of the disease, such as the formation of gummata, deep unsymmetrical ulceration of the skin or mucous membranes, and various deep-seated visceral affections. Only a comparatively small proportion of those infected suffer from tertiary symptoms.

Between the secondary and tertiary stages an interval of perfect health may intervene, perhaps interrupted by occasional recurrences of the secondary symptoms. During the intervals of health, the syphilis is said to be "*latent*."

The **duration of these various stages** is uncertain. According to Berkeley Hill, the period of incubation in thirty-seven trustworthy cases of experimental inoculation collected from various sources, varied from ten to forty-six days, the average being twenty-four. The most common periods were twenty-five and twenty-eight days. The duration of the primary symptoms depends very much on treatment, but it seldom extends beyond a month or six weeks. The secondary symptoms commence from two to three months after inoculation, and last from a few weeks to a year. The period of development, and the duration of the tertiary symptoms, are too indefinite to be stated with any approach to accuracy. Symptoms classed as tertiary may appear immediately after the secondary signs, or may prove fatal after many years of apparent health.

One attack of syphilis, as a rule, confers upon the patient subsequent **immunity** from the primary or secondary forms of the disease. Second attacks are, however, not unknown, but they are not more frequent than in small-pox or measles. When the patient has the misfortune to suffer a second time, the symptoms are never so severe as in the first attack.

From a consideration of the course of the disease as above described, with its periods of incubation, and of invasion, its sequelæ, and the immunity it confers from a second attack, Jonathan Hutchinson long ago pointed out its analogy to the specific fevers. He regarded the disease as a specific fever of a very chronic nature and irregular course. As at the present time the acute specific

diseases and syphilis are equally included in the group of general infective processes, Hutchinson's views may be said to be generally accepted.

Origin of Syphilis.—It would be altogether foreign to the scope of this work were I to enter into the very curious and interesting question as to the origin of syphilis, a subject that admits of much dispute, and which has been keenly argued. The disease first attracted public attention in Europe towards the end of the fifteenth century, in consequence of a virulent outbreak which occurred amongst the troops of Charles VIII. of France, during the siege of Naples in 1494. At the time it was undoubtedly considered a new disease, and many of the writers of the period believed it to have been introduced from the newly-discovered continent of America. There is, however, no trustworthy evidence to support this theory. A careful study of the ancient medical writers has led many authorities to the belief that syphilis existed in their time, though the definite relation of the various secondary and tertiary phenomena to the primary sore was not recognized. If it existed previously to the great outbreak in Europe in 1493 and 1494, it is probable that it was in a mild or modified form, different from what we now observe, and that about that time it suddenly assumed greater intensity, all its symptoms being aggravated in a remarkable manner, and presenting characters which had not previously been alluded to, but which have often been reproduced in modern times; as, for instance, in those severe forms that were observed in the British armies during the Peninsular war, and, according to Larrey, among the French troops during Napoleon's German campaigns.

CONTAGION OF SYPHILIS.—Syphilis is communicable, 1st, by the direct inoculation of any fluid containing the specific virus; and 2ndly, from parents to their offspring.

1. **Direct Inoculation.**—In discussing this question, it is necessary to consider first what fluids or secretions of a syphilitic subject contain the virus, and secondly, the various ways in which the virus may be communicated from one individual to another.

That the discharge from the primary sore, whether it be thick and purulent, or simply serous, is inoculable, is too well known to require further notice.

The contagiousness of the discharges from secondary syphilitic sores has also been demonstrated by numerous experiments. The thin secretion from mucous tubercles of the vagina, anus, and mouth has frequently been shown to be capable of causing infection. The blood itself, in more than one instance, has been inoculated with success. Professor Pellizzari, of Florence, inoculated a young Surgeon, Dr. Bargioni, on the 6th of February, 1860, with blood taken from the vein of a woman suffering from syphilitic eruptions. The site of the inoculation, which was carefully protected by a watch-glass cover, remained quiet for twenty-five days; then a papule developed, which in forty-four days became an ulcer with hard base. On the sixty-fifth day after inoculation, a roseola broke out on the trunk.

Some uncertainty still exists as to whether the natural secretions of syphilitic persons are contagious of themselves, or become so by admixture with the blood or the discharge of local syphilitic affections. The saliva, the milk, and the semen have been inoculated on healthy individuals with almost invariably negative results. So far, therefore, it may be said to be proved beyond a doubt that the discharges from all secondary syphilitic affections, and the blood of patients suffering from active syphilis, contain the specific virus, but

there is no definite evidence to show that the secretions of apparently healthy mucous surfaces or glands in a syphilitic subject are capable of transmitting the disease.

The actual inoculation of the virus may take place in many ways. There is no reason to believe that it can enter the system through an unbroken epithelial surface. On the other hand, it readily infects any surface from which the epithelium has been removed by abrasion, vesication, or ulceration. Wounds or punctures are also readily inoculated.

Infection naturally takes place in most cases during coitus, and the primary manifestation is usually situated in those parts most likely to suffer from abrasion during the act. Whether the vaginal mucus of a syphilitic woman is capable of conveying the poison, if she be not at the same time suffering from primary sores or mucous tubercles, is uncertain.

The next most common source of infection is the secretion of the mouth. As before stated, the saliva alone has not been proved to be capable of conveying the poison, but if mingled with the secretion from mucous tubercles or the discharges from secondary ulcerations of the tongue or tonsils, it is undoubtedly infectious. The disease is then most commonly communicated by kissing, and the primary sore appears on the lip or cheek. Authentic cases are also on record in which the infection has been carried by drinking vessels, spoons, or pipes, and in one case the primary sore appeared on the knuckle in a cut received whilst striking the affected person on the mouth. Infants suffering from inherited syphilis have infected their wet-nurses, the primary manifestation appearing at the nipple. This point is one of very great importance, inasmuch as actions for damages have been brought by women who have stated that they have become diseased from the child they have nursed. There are so many cases of the kind recorded, that there can be no doubt as to the possibility of the occurrence. Hunter and Lawrence related cases in which an infected child communicated the disease to several nurses in succession; in Hunter's cases three wet nurses were successively infected, two of whom gave the disease again to their own children. The disease is especially apt to be communicated in this way, if the nurse have any crack or abrasion upon her nipple, and the infant sores in the mouth. Colles, however, who had great experience in syphilis, states that the disease may be communicated to the nurse from an infected child by mere contact, without excoriation; but when we consider that a period of three weeks or more may intervene between inoculation and the appearance of any sign of the disease, the statement must be accepted with considerable caution.

Whether a wet-nurse can infect the child she suckles through the medium of the milk is a more doubtful question, and cannot be said to be finally determined. Ricord and many others of equal authority believe it to be possible, and my own opinion is that syphilis has been transmitted in this way, though very rarely. In *Ranking's Abstract*, vol. iv., a number of cases are recorded in proof of its occurrence.

Primary sores on the finger are unfortunately by no means uncommon amongst Surgeons and accoucheurs, who become infected whilst dressing syphilitic sores or attending diseased women in labour. Washerwomen are said to have been infected in the hands by washing linen soiled by the discharges from venereal sores.

The transmission of the disease by *vaccination* with lymph taken from a

child suffering from congenital syphilis was until comparatively recently denied by most authorities. It has now, however, been placed beyond a doubt that the disease can be thus communicated. One of the most unquestionable of these accidents is that which occurred in the sub-Apennine valley of Rivalta in Piedmont, in 1861. Dr. Pacchiotti, of Turin, who was employed by the Italian Government to report on the attack, published an account of it. The facts are shortly as follows :—In May, 1861, an apparently healthy child, named Chiabrera, was vaccinated at Rivalta with lymph sent from Acqui for the purpose. Ten days after this vaccination—on June 7th—forty-six healthy children were vaccinated at one sitting from this child. Again, on the 12th June, seventeen other healthy children were vaccinated from one of the forty-six. Thirty-nine of the first series of forty-six, and seven of the second series of seventeen, received syphilis with the vaccine disease, making a total of forty-six out of sixty-three children simultaneously inoculated with syphilis in a mountain village. Some months elapsed before the vaccination was suspected to have been the source of the children's bad health. By the 7th October, when attention was drawn to this spreading disease, six of the forty-six syphilized children had died without receiving any treatment, fourteen were recovering, and three were in a precarious condition. Twenty-three were dispersed through the country, and their condition was unknown until further researches traced them out. In addition to the children, twenty women suckling them were inoculated with syphilis from the children ; through the mothers, the disease had reached some of the husbands and even the elder children of the different families. The history of this outbreak of vaccino-syphilis shows that the disease appears in only a certain proportion of those inoculated with the lymph. It has been attempted to explain this by supposing that syphilis is spread only when blood is mixed with the lymph, and that pure lymph will not convey syphilis even when taken from a syphilitic child. The evidence, however, at the present time is not sufficient to prove this definitively, but it is enough to impress upon every vaccinator the necessity of not only carefully examining every vaccinifer for syphilis, but also of obtaining the lymph free from contamination with blood, even when taken from an apparently healthy child.

Syphilis has been transmitted in one well-authenticated case (see p. 277) by *skin-grafting*. In this operation the grafts are cut of sufficient thickness just to draw blood, so that there is no difficulty in understanding how the poison may be conveyed from one person to another.

2. **Transmission of Syphilis from Parent to Offspring.**—The mode of communication of syphilis to the ovum, or to the fœtus in utero, is an investigation that has much occupied the attention of Surgeons, and is of considerable practical interest. It has been considered probable that the poison may be communicated to the embryo in at least four ways : *viz.*, 1, the father may have a constitutional taint of which he has been imperfectly cured, and, without communicating any syphilitic disease to his wife, may be the parent of an offspring that exhibits indications of being infected ; or, 2, the mother, having a similar constitutional disease, may in like manner taint her own offspring ; or, 3, the diseased child may be born of parents, both of whom are constitutionally infected ; or, 4, the mother may become pregnant with a healthy embryo, but, afterwards contracting syphilis, may transmit it to her offspring.

There are very good reasons for believing that the disease does not pass from the father to the child without also implicating the mother. In the first place, this faculty is shared by no other contagious disease. No father can give his offspring small-pox, though the mother frequently communicates that disease to her fœtus. In the next place, it is well known, as Colles of Dublin long ago pointed out, that a congenitally syphilitic child never locally infects its mother, though it will transmit its disease readily to a wet-nurse; this apparent exemption of the mother being due to the fact that she has been already infected. Again, the symptoms of syphilis are often exceedingly mild in women, and are constantly overlooked. Hence, in the present state of our knowledge, it is safer to conclude that the father infects the mother, and that she transmits her disease to the offspring.

Ricord, however, states that a mother, pregnant with a syphilitic fœtus, the offspring of a father labouring under constitutional disease, can be infected through it without herself having had primary syphilis; and Jonathan Hutchinson has advanced a considerable amount of evidence in support of this doctrine, which, nevertheless, fails to carry conviction to my mind that such communication ever takes place.

Duration of Transmissive Power in the Parents.—This question is one of great importance as bearing on the question of marriage of persons who have suffered from syphilis. There can be no doubt that the power to transmit the disease lasts during the whole time that the secondary manifestations are present. There is equally strong evidence for believing that during the tertiary stage the parent does *not* infect his offspring. I know instances of men who had contracted syphilis before marriage, and had been imperfectly cured, and had for many years (ten, fifteen, or even twenty) occasionally suffered from outbreaks of cutaneous syphilides, gummata, and other varieties of the advanced form of the disease, and yet have been the parents of perfectly healthy children, and have never infected their wives. Cases have, however, been recorded in which the wife and her offspring have been affected after very long periods, extending even to ten or twelve years, even when no evident signs of the disease were present in the parents; and, on the other hand, marriage two years after infection has frequently been followed by the production of healthy children. When, therefore, the question is put to the Surgeon, When may a patient marry who has suffered from constitutional syphilis? it is by no means always easy to give a direct and immediate answer. In answering, the Surgeon must be very cautious; he must bear in mind that the health and happiness of a woman and the future of a family are often dependent on his reply; and that, should he give his consent to the union and evil consequences follow, the whole responsibility will be thrown upon him. It may be stated generally in the first place, that if any of the local symptoms of syphilis are developing themselves, the affected person should not marry, whatever time has elapsed since the commencement of the attack. As a general rule, even if all local symptoms have disappeared, it is advisable not to marry till three years after the commencement of the disease. If, however, there are reasons which make it difficult to delay so long, the Surgeon may give his consent to the patient's marrying two years after the time of infection, provided he have shown no distinct symptoms of active syphilis in the preceding twelve months. Marriage under two years is most frequently followed by the production of diseased children, and should never

be consented to unless the attack has been of a very slight character and no symptoms have been observed for a year.

PROGRESS OF ACQUIRED SYPHILIS. **First Stage. Period of Incubation.**—The effects of contagion are not immediately manifested. The time that intervenes between inoculation and activity of the poison is called the *incubation period.* It may be occupied in three ways. If the vehicle containing the virus be of a non-irritating character, the broken surface heals, and all trace of the inoculation disappears until the incubation is completed; or, as the vehicle of the virus is often pus or discharge of an irritating kind, it may cause immediate inflammation at the point of inoculation. This irritation subsides in a short time, and the part then remains quiet until the incubation is complete, when the syphilitic poison betrays its presence by characteristic phenomena. An experiment of Vidal's illustrates this. He inoculated the matter of a pustular syphilitic eruption on the arm of a medical student, which produced a pustule in a couple of days; this healed over in about a fortnight, and the experiment was supposed to have failed until the thirty-fifth day; a papule then developed, which subsequently ulcerated, and general syphilis followed in due course. If the syphilitic virus be carried in the pus of a local contagious chancre, the time of incubation is often occupied by the course of a chancre, which may or may not have healed over when the syphilitic poison produces its characteristic effect. This series of events—first a suppurating contagious sore, and then induration forming in the base of the sore, or in its scar if the sore have already healed—is perhaps almost as common as the inoculation of syphilis unaccompanied by immediate local irritation; but the two morbid processes have no connection with each other, and are only accidentally co-existent.

The length of this time of inactivity varies in different persons; it is commonly twenty-five days. The shortest known period before the poison began to reveal its presence has been ten days, and the longest forty-six days. The most important question with regard to this stage of the disease is, how long does the poison remain localized at the seat of inoculation before entering the circulation? No certain answer can be given to this question, but it is probable that the period between inoculation and general infection is very short. Berkeley Hill records a case in which he freely destroyed the surface of the wound left by a rupture of the frænum about twelve hours after infection, but in spite of this general syphilis followed. Ricord, who at one time believed that destruction of the seat of inoculation within five days would prevent the general disease, afterwards completely abandoned this view, and came to the conclusion that destruction of the seat of infection is useless. Experiments on the inoculation of vaccine lymph on the human subject, and the virus of glanders on horses, have shown that the time that elapses between the local introduction of the virus and its entrance into the circulation is very short. In glanders, the excision of the seat of inoculation one minute after the poison was inserted failed to arrest the development of the disease. Those cases, therefore, in which general syphilis is reported to have been cured by excision of the primary sore, cannot be accepted without further evidence.

Second Stage. Appearance of the Initial Manifestation or Primary Sore.—When the period of incubation is past, a peculiar chronic inflammatory process, accompanied by the growth of new tissue, takes place in the seat of inoculation beneath the epithelium, if that be intact, or in the

tissues forming the base of the ulcer, if the inoculation has been immediately followed by the formation of a sore consequent upon the simultaneous introduction of the poison of the non-infecting chancre or other irritating matter. Should such a sore have healed, the new growth commences in the scar. The new tissue may be of almost cartilaginous hardness. Microscopic examination shows it to be formed by an infiltration of the connective tissue with small round cells. With these larger cells containing a single nucleus are found, and not uncommonly multinuclear cells of considerable size are met with. These differ from the giant cells of tubercle in being smaller and more regular in outline. It is the formation of this growth that forms the most distinctive features of the true syphilitic sore. The simple chancre is formed by a true process of ulceration. There is destruction of tissue from the first, and such apparent increase as there may be results merely from inflammatory exudation, and the cells infiltrating the tissues are apparently all migrated white corpuscles, and show no signs of higher development. In the initial manifestation of syphilis, in addition to the small round cells, larger cells evidently undergoing development are met with. In the simple chancre there is from the first evident loss of substance; in the hard sore there may be distinct increase of tissue even when ulceration is taking place. The new growth in the initial manifestation of syphilis is imperfectly vascularized. The walls of the small arteries and veins in the infected tissue are sometimes found to be thickened, and the lumen obstructed by a growth from the endothelium. Consequently the indurated tissue tends readily to degenerate and break down.

Clinically, the initial manifestation assumes two forms,—the desquamating papule, and the indurated chancre.

The **desquamating papule** appears at the point of inoculation as an elevated hard dark-red or copper-coloured spot distinctly elevated above the surface, with slight desquamation of the epithelium covering it. At first it is very small, but it may gradually extend till it reaches half an inch in diameter. It is dense and hard, its edges are sharply defined; it is practically painless, causing at most a slight itching. It occurs most frequently where it is little exposed to friction or to the irritation of accumulated secretions. If irritated in any way it readily ulcerates and then becomes an indurated chancre. In fact it rarely remains as a papule to the end. From its painless nature, if ulceration does not occur, it may run its course and subside without attracting the attention of the patient.

The **Indurated or Hunterian Chancre** commences as a papule, or may begin as an apparently simple sore which becomes indurated when the period of incubation is past. It assumes two forms dependent on the amount of the surrounding induration. In one form the sore is superficial, and the hardness, which is clearly defined, extends but little beyond it. In this variety, the sore is the most prominent feature, and the induration may even be difficult to detect, sometimes assuming the form described by Ricord as "parchment induration." The discharge, if the sore be kept clean and free from irritation, is merely serous, and under the microscope shows granular *débris* with a few epithelium scales. If the surface be irritated by dirt, or the friction of clothing, or by any substance used as a dressing, it rapidly becomes purulent. The extension of the ulceration is slow and painless. The superficial sore forms the most common variety of the initial manifestation. It occurs

usually on moist surfaces as the glans or inside of the prepuce in the male, or the labia in the female.

The second form of indurated sore is that most properly described as the "true Hunterian chancre." It is surrounded by a dense mass of induration extending deeply into the tissues. It is considerably elevated above the surrounding parts, and the surface is often slightly cup-shaped. Grasped between the fingers it feels almost like a piece of cartilage, the limits of the induration being clearly and sharply defined, and the surrounding tissues free from inflammation. It is usually painless, and its surface is often almost dry, there being merely a very slight serous discharge. It is most common on the glans or on the corona. Every modification may be met with between these two forms of the indurated sore. It has been maintained by Surgeons of great authority that induration at the site of inoculation may occasionally be absent. It is certainly in some rare cases so slight that it is detected with difficulty, but it is doubtful if it is ever wholly wanting.

As soon as the primary sore makes its appearance, the patient acquires an immunity from re-inoculation of the poison, the discharge from an indurated sore not being inoculable on the patient himself under ordinary circumstances. If, however, the surface be irritated mechanically, by the application of irritating dressings or from want of cleanliness, to such an extent that the discharge becomes purulent, it will then as a rule become auto-inoculable, the resulting sore resembling a soft chancre in appearance, and not presenting the characteristic features of the hard chancre. The non-inoculability of the discharge from an inflamed hard sore has been used as a means of diagnosis between the hard and the soft chancre, but in cases in which doubt existed the sore would probably be suppurating from irritation, and consequently an error might easily arise.

Number.—The primary syphilitic sore is almost invariably single. This fact is readily explained by its non-inoculability on the patient himself. Arthur Cooper states that of 103 cases of early syphilis admitted into the Male Lock Hospital, in 91 there was only one initial lesion, 7 had two sores, and 5 had more than two.

Situation.—The indurated primary ulcers of syphilis are most frequent on the *genitals*, but not so exclusively limited to those parts as are local venereal sores, because syphilis is communicated in various ways besides sexual intercourse. They may appear on any part of the body. Fournier found that, of 472 cases of inoculation in men, 314 were on the prepuce and glans penis, 109 on other parts of the male organ, 12 only in the mouth, 6 on the hands and fingers, and a few on the eyelids, tonsil, and navel.

The **Urethral Chancre** is usually situated just within the orifice of the canal, and may be seen on pressing open its lips, in the form of a small sore, which occasionally creeps out upon the glans. Sometimes it is more deeply seated, so as to be out of sight; when this is the case, a discharge, occasionally tinged with blood, appears in small quantities from the urethra; at a little distance up the canal there will usually be felt, on grasping the organ, a circumscribed indurated spot, which is somewhat painful on pressure and after micturition. It is the presence of chancres in this canal that formerly led to the supposition of the identity of syphilis and gonorrhœa, an error which was disproved by the test of inoculation; the discharge from urethral chancre producing the typical sore, that from gonorrhœa giving no result when in-

troduced into the skin. The existence of chancre within the urethra may be suspected if the urethral discharge be small in quantity, serous in character, and tinged with blood. The chancre may be detected by everting the edges of the urethra, or, if situated too high up the canal to be seen without the help of the endoscope, by being felt, hard and nodulated, through its coats. Care must be taken not to mistake the inflammatory induration sometimes occurring around the urethra in gonorrhœa for that of a hard sore.

In some cases of unnatural depravity chancres are met with at the margin of the **anus**. In this situation they present nothing peculiar.

In **women** chancres are very rare on the vaginal wall; about four per cent. are said to occur on the cervix uteri, and the remainder on the external organs of generation.

Labial and **Facial Chancres** are by no means uncommon, being usually the result of the inoculation of a small crack on the lip or excoriation of the skin of the face with the discharge from mucous tubercles in the mouth of an infected person. Chancres on the lip may possibly result also from drinking or using a spoon after a syphilized person, or smoking the same pipe. These sores are often very deceptive, the raised and indurated base causing them closely to resemble epithelioma. They frequently show a tendency to the formation of a soft fungating growth, all induration being absent. In a case of chancre of the cheek lately admitted into University College Hospital, the sore was as large as half-a-crown, and raised abruptly above the surrounding skin for about a quarter of an inch. It was scarcely indurated, and the discharge was serous and bloody, mixed with a little pus. The surface had a great tendency to become covered with scab. In other cases the induration may be of the same character as in the Hunterian sore on the penis. The diagnosis can usually be made by attention to the foul surface, hard base, and persistent character of the sore, and by the invariable presence of indolent enlargement of the nearest lymphatic glands commencing at the same time as the appearance of the sore or at most a few days later. Later on, the appearance of skin eruptions will make the nature of the case evident. From cancer, chancre of the lip can usually be distinguished by the age and sex of the patient, as it is most commonly met with in girls and young women who have not reached the age for cancer; indeed, in women at any period of life cancer of the lip is extremely rare. Chancres have been met with even on the **tongue** and **tonsil.**

I would especially caution the Surgeon not to be misled in his diagnosis by the modest look or the respectable station in life of the infected woman. In this, as in all other cases of venereal disease, he must make an independent diagnosis without regard to social considerations or to the statements, often purposely misleading, made by the patient.

Syphilis not unfrequently occurs amongst Surgeons and accoucheurs as a consequence of inoculation on the **fingers**, during the dressing of a venereal sore, or the delivery of a diseased woman; and is occasionally met with also among non-professional persons. It usually appears as a small sore by the side of the nail and under its matrix, with much swelling, redness, and pain in the finger, which becomes bulbous; indolent swelling of the glands at the elbow and in the axilla soon follows. If the nature of the disease be not recognized, the ulceration will creep round the tip of the finger, will have a foul and sloughy look, with exquisite tenderness, and, resisting all ordinary treatment, may be

set down as malignant; on which supposition amputation of the finger has been proposed and practised. I have seen at least four cases in which this extreme measure has been proposed, but in which, by a timely discovery of the true nature of the affection, the finger was saved. In the earlier stages a chancre on the finger is likely to be mistaken for a whitlow.

Variations in the Sore as the result of Irritation.—As the result of irritation, the normal serous discharge of a hard chancre becomes purulent. If the irritation be more severe, and especially if inefficient caustics, as nitrate of silver, have been applied, the surrounding tissues become infiltrated and swollen so as to obscure the characteristic sharply defined edge of the induration. In such cases it is often impossible to make a diagnosis until the inflammation has been subdued by proper treatment.

Hard sores rarely if ever assume a sloughing form. Phagedænic ulceration is, however, not uncommon (see p. 1110).

Prognosis from the Appearance of the Primary Sore.—Every patient who has the initial manifestation is already suffering from constitutional syphilis, and nothing can prevent the development of secondary symptoms. These may be so slight as to be scarcely noticeable, or so severe as to endanger life. Much induration is often thought to precede a severe course of syphilis, and possibly this may be true; but the most severe symptoms have also followed small superficial sores, so that it is not safe to draw any conclusion from the appearance of the initial manifestation.

Course of the Indurated Sore.—If unmodified by treatment, the initial manifestation tends slowly to disappear, the surrounding induration melting away and the sore healing, a scar being left behind, which is more or less marked, according to the extent and depth of the ulceration that has accompanied the process. The simple desquamating papule may leave no recognizable scar. The length of time which may elapse before spontaneous disappearance of the induration takes place is uncertain, but it is rarely, if ever, under two months.

Indolent Enlargement of the Lymphatic Glands.—The so-called *indolent bubo* is the next change to follow induration at the seat of inoculation. The time at which this follows the appearance of the initial manifestation is variously stated at from seven to eleven days. Most commonly the glands are found already enlarged when the patient first presents himself, and form a most important element in the diagnosis. One gland enlarges first and several follow; the glands are painless, or only very slightly tender, and the hardness is such that they are often described as feeling like bullets. The skin over them is unaltered, and the individual glands can be clearly distinguished, even when they form together a considerable mass, there being no doughy swelling about them as in the acute suppurating bubo. In rare cases, if the sore be irritated so that it is suppurating freely, or if the patient have unwisely taken violent exercise, as dancing, riding, and the like, suppuration may follow, and an abscess form around the glands. The pus from such an abscess, however, is never auto-inoculable like that from the virulent bubo following a soft chancre. If the point of contagion be situated near the middle line, at the frænum for instance, the glands in both groins are often enlarged.

Enlargement of Dorsal Lymphatics of Penis.—Simultaneously with the occurrence of glandular enlargement some induration and thickening of

the lymphatics which pass along the dorsum of the penis can often be detected, and must be looked upon as good evidence of the syphilitic nature of a doubtful sore. The lymphatic is usually felt as a fine hard cord, but occasionally it may reach the size of a cedar pencil.

SECONDARY AND TERTIARY CONSTITUTIONAL MANIFESTATIONS OF SYPHILIS.

In describing the constitutional manifestations of syphilis it will be most convenient to give first an outline of the general pathology and the ordinary course of the disease and its treatment, and subsequently to consider in detail the special syphilitic affections of the various textures and organs.

General Pathology and Progress of Syphilis.—After the appearance of the initial manifestation there is usually an interval of from five to seven weeks before any further characteristic symptoms are developed. This has been termed "the period of second incubation." During this time there is in most cases some disturbance of health; the patient becomes pale, and suffers from malaise or a general sense of indisposition, often with some loss of flesh. Neuralgic pains in the head and other parts of the body are common. Sometimes there is distinct but slight febrile disturbance just before the cutaneous eruptions make their appearance. This is seldom sufficiently marked to attract attention, but in very rare instances the fever may be high and accompanied by delirium.

At the end of this period, often before the primary sore is healed, the secondary manifestations of the disease make their appearance. These consist of various superficial affections of the skin and mucous membranes, usually appearing more or less symmetrically. In the skin the early syphilitic eruptions or syphilides present the following gradations. In the simplest form there is hyperæmia of the papillæ in localized spots with some retardation of the blood-stream. We consequently get a red patch of a somewhat dusky colour not perceptibly elevated above the surface. On pressing on the discoloured area the red tint disappears, and a faint brownish or copper-coloured stain is left behind. This is presumably due to staining of the tissues by the pigment from a few corpuscles which have escaped from the distended vessels. This form of eruption is described as *macular syphilide* or *syphilitic roseola*. It is the most common and the earliest of all the cutaneous affections. It occurs also on mucous membranes, and is usually of short duration.

If the hyperæmia continues for a longer time, the papillæ become swollen and an increased growth of epithelium takes place on their surface. There is thus formed a red patch, slightly elevated and covered with a branny or scaly layer of desquamating epithelium. This is the *squamous syphilide* or *syphilitic psoriasis*, a common early syphilitic eruption. If the eruption occurs in a moist place, as in the neighbourhood of the anus or on a mucous membrane, the hypertrophy of the papillæ is usually more marked, and the new epithelium instead of forming dry scales separates early or forms a sodden white mass on the surface of the patch. Occasionally the papillary aspect of the growth is very distinct. This is the *mucous tubercle* or *flat condyloma*, and when the eruption is general every gradation may be traced between it and the squamous syphilide, according to the degree of moisture of the part in which the patch is situated.

The next degree of the process is the syphilitic *papule* or *papular syphilide*.

This is the result of a coagulable inflammatory exudation into the papillæ of the skin. It forms a hard, red, elevated patch, usually of small size and covered by a bran-like desquamation of the epithelium. It merges insensibly into the squamous syphilide, or, if in a moist part, into the mucous tubercle.

If the process be more acute, the serum from the exudation raises the cuticle and a vesicle is formed. *Vesicular syphilide* is a rare form of eruption. Should it be still more acute, migrating corpuscles penetrate the Malpighian layer of the epithelium, and mixing with the serum in the vesicle, convert it into a pustule, and there is then developed the *pustular syphilide*. When the pustules occur in the early stages of syphilis, they dry up and form scabs, beneath which no ulceration takes place, and no scars are left when they are healed. On mucous membranes, from the thinness and softness of the epithelium, the superficial layer is very early cast off, and there is thus formed the small superficial ulcer commonly met with on the tongue and lip.

All the early syphilitic eruptions are merely modifications of one pathological process, differing in degree but not in nature. They occur in all parts of the body, and often in situations which are not affected by simple eruptions of the same character; thus, for instance, the squamous syphilide is common on the palms of the hands, the soles of the feet, and the flexure of joints. They present also the great peculiarity of causing little or no itching or irritation. More than one form of eruption may be present at the same time, and in this again they differ from simple skin diseases.

With the skin eruptions there is, in the majority of cases, some affection of the *throat*. With the roseola of the skin there is usually some redness and dryness of the fauces, as if a similar eruption was taking place there also. Later on ulceration of the *tonsils* very commonly takes place. The ulcers are, as a rule, symmetrical; they have sharply-cut edges and a grey floor, and the mucous membrane round is reddened. They cause singularly little pain in most cases, and have no tendency in this stage of the disease to extend far beyond the surface of the tonsil, or to cause extensive destruction of the pillars of the fauces or soft palate.

The remaining symptoms belonging to the secondary stage of the disease are, *loss of hair*, pains in the *bones*, periostitis without any tendency to terminate in suppuration, and *inflammation of the iris*.

The most common of the foregoing symptoms is roseola followed by papular and squamous syphilide, with ulceration of the throat; mucous tubercles, loss of hair, and periostitis are common but by no means constant; iritis is, fortunately, met with only in a small percentage of cases.

During the time the eruptions are making their appearance chronic enlargement, with induration, of the *lymphatic glands* throughout the body, is not uncommon. The patient is usually anæmic and thin, but not necessarily so.

The secondary stage may end in two months or extend over a year. Not uncommonly after complete disappearance of all symptoms and an interval of some months of apparent health, a relapse takes place, indicated by a return of some of the secondary eruptions. When the secondary stage has come to an end the patient may never suffer again from any signs of the disease, or he may pass on directly to the development of those symptoms which are classed as tertiary. In many cases an interval of months or years intervenes between the secondary and the tertiary stages, during which occasional relapses of the secondary symptoms may occur. In other cases, again, the tertiary affections

may appear before the secondary signs have subsided. Thus there is no distinct line of demarcation between secondary and tertiary syphilis.

The **Tertiary Stage of Syphilis** is characterized by the appearance of ulcers on the skin and mucous membranes, usually unsymmetrical, and having a tendency to spread widely, and to cause considerable destruction of tissue: by certain chronic degenerative changes in the blood-vessels; by chronic fibroid induration and hyperplasia of organs and tissues, and by the development of masses of new tissue forming definite tumours prone to early degeneration—*syphilitic gummata* or *syphilomata.*

The *ulcers on the skin* begin in various ways. First, they may arise in much the same way as the secondary eruptions. A localized patch of the skin, a quarter of an inch or more in diameter, becomes inflamed, usually vesication takes place, the fluid in the bleb becomes rapidly purulent and then dries up, leaving a dry adherent scab which gradually increases in thickness and diameter. If this be removed, a circular ulceration of the cutis is found beneath, which may slowly spread with the formation of a fresh scab. This form of eruption, known as *rupia*, occurs scattered over the whole body, and in this resembles a secondary eruption. In fact, it forms an intermediate link between secondary and tertiary affections.

Secondly, small gummata form in the cutis vera, forming flat dusky-red or copper-coloured elevations, known as *tubercular syphilide*, or *syphilitic tubercles.* These soften in the centre, and an ulcer forms which may spread slowly.

Thirdly, a gumma may form in the subcutaneous tissue; which softens, becomes adherent to the skin, and opens on the surface by ulceration, leaving a deep excavated cavity, with an adherent yellow slough.

Lastly, in syphilitic subjects, a simple injury to the skin may lead to a spreading ulcer. This form is most common on the leg. All tertiary ulcers tend to spread slowly, often extending on one side while healing on the other. They thus are often crescentic or serpiginous in form.

The *changes observed in the smaller arteries* consist of a gradual narrowing of the lumen by a growth apparently originating by proliferation of the endothelium. The external coat is also thickened, but in a slighter degree. These changes have been observed in the cerebral and renal arteries of medium size, and in the smaller vessels in the neighbourhood of gummata. In the larger arteries no distinctive changes are met with, but it is a well-known fact that the great majority of aneurisms of the larger vessels in young subjects occur in those who have suffered from constitutional syphilis.

Overgrowth of the connective tissue is met with in the lung, liver, spleen, testicle, and other organs, and with it must be classed the diffuse hypertrophy of bone, which is not an uncommon consequence of syphilis. An organ affected in this way is tougher and harder than natural, and at first increased in bulk. If it is enclosed in a fibrous capsule, as the liver or testicle, this is thickened and opaque, sometimes uniformly, sometimes in patches. When the organ is covered with a serous membrane this also shows signs of chronic inflammation; thus a syphilitic testicle is almost invariably surrounded by a hydrocele often divided into separate sacs by adhesions between the visceral and parietal layers of the tunica vaginalis. In a later stage the affected organ may shrink and become puckered on the surface. A section shows, in the early stage of enlargement, that the proper structure is infiltrated by a whitish or semi-

transparent material of considerable firmness lying in the natural situations of the connective tissue and following the lines of the vessels. In the testicle the septa may thus be increased to half a line or more in thickness. In the later stages, when the active process has ceased, dense cicatricial bands of fibrous tissue may pass through the organ in various directions leading to puckered scars on the surface. The process is painless, and the performance of the natural function of the organ is diminished in proportion to the destruction of its proper structure by the pressure of the new growth.

The microscopic appearances presented by organs thus affected are those of chronic interstitial inflammation. The interstitial connective tissue, sometimes throughout the affected organ, sometimes in bands or patches, is found to be infiltrated with small round cells, between which is a delicate stroma, usually finely fibrillated. Vessels of new formation are abundantly present in the new tissue. The growth seems to commence round the vessels and to infiltrate along their course. At a later stage it becomes developed into dense fibroid tissue, and at the same time undergoes considerable contraction, which may lead to deformity and puckering of the affected organ. The normal structures of the part are pressed upon by the growth, and may degenerate and be completely absorbed in parts. The original vessels show the changes just described, and are frequently obliterated.

This process manifests itself in bone by a gradual enlargement extending over a considerable area, and accompanied by a great increase in density of the structure (sclerosis of bone). The Haversian canals are narrowed, and in many are completely obliterated, and thus from want of blood-supply death of a portion of bone may take place (syphilitic necrosis). The bones of the skull furnish some of the best specimens of this change.

The most characteristic pathological product of tertiary syphilis is the **Gumma**, or, as it is sometimes called, the *syphiloma* or *syphilitic granuloma*. A gumma commences by a localized process essentially similar to the diffuse form just described, namely, an infiltration of the connective tissue of the affected part with small round cells. These cells may be in part migrated white corpuscles, and in part formed by proliferation of the original connective tissue corpuscles. It is impossible to say to what extent they owe their origin to these two sources. Small multinucleated cells are often present. New vessels are formed amongst the cells, and thus a tissue is developed having the characters of granulation tissue. This continues to increase in quantity till the special structure of the part, such as epithelium in a gland, striated fibres in muscle, fat cells in adipose tissue, or the compact tissue of bone, disappear in the affected area, being destroyed and absorbed in consequence of the pressure of the invading growth. Thus a nodule is formed, composed of small round cells, between which is an intercellular substance, small in amount and usually distinctly fibrillated, so as to give the new tissue considerable toughness. The gumma in this stage is abundantly vascular. The new tissue exceeds in bulk that which it has replaced, and thus forms a distinct tumour. It increases by a progressive infiltration of the surrounding structures, and not, as in tubercle, by the formation of new nodules which coalesce with that first formed. The growth continues till the gumma may reach the size of a walnut; but long before this—in fact, soon after the gumma becomes recognizable—degenerative changes have taken place in its structure. These arise, not, as in tubercle, from the absence of vessels in the new tissue, but, as

has been pointed out by Greenfield, from a gradual obliteration of the small arteries entering the mass by the process, already described, of proliferation of the endothelium and thickening of the external coat. Probably also the pressure of the new cells, closely packed together, obstructs the circulation through the capillaries. As a result of the starving of the new tissue thus brought about, fatty degeneration takes place. The cells wither and become filled with fat granules, and finally are represented merely by fatty *débris*, amongst which the individual elements are not recognizable. The intercellular tissue, when fibrillated, undergoes but little change, and thus the caseous mass retains a considerable degree of toughness, very different from that of yellow tubercle. The caseation may follow very closely on the growth; but while growing, a gumma is always surrounded by a zone of cell-infiltration of the neighbouring connective tissue, with vessels of new formation amongst the cells. The caseated centre of an old gumma often contains crystals of cholesterine. Gummata vary somewhat in consistence according to the degree of fibrillation of the intercellular substance. In some cases mucous softening seems to take place and the gumma may be almost gelatinous in consistence.

Fig. 403.—Syphilitic Gumma, showing a large vessel becoming obliterated by proliferation of the endothelium.

The ultimate fate of a gumma varies in different parts and under different circumstances. Even after caseation and partial softening it may, under proper treatment, be completely absorbed, leaving a depressed fibrous cicatrix behind it. In other cases, especially in gummata of the subcutaneous tissue, bone and muscle, softening takes place, followed by suppuration round the softened mass. The pus finally reaches the surface, and the tissue of the gumma is cast off as a slough. The slough is tenacious and slow to separate even after the pus has been discharged. It has been very aptly compared to a piece of wet wash-leather. In this it differs entirely from caseated tubercle, which, under similar circumstances, forms a granular mass which can readily be scraped away with a sharp spoon. In the liver, testicle and brain growth may cease, and the surrounding zone of cell-infiltration, instead of degenerating, may be developed into a fibrous capsule, which may enclose the caseated mass and completely encyst it. In this condition it may remain permanently without causing further mischief. Calcification occasionally takes place, but is far from common.

A fully developed gumma, free from softening, presents to the naked eye on section the following appearances. The cut surface is smooth, of a pale straw yellow colour, of tough consistence, and on scraping yields but a small amount of granular *débris*, sometimes scarcely any. Though its outline is tolerably well defined, it can always be seen that the growth is not circumscribed, but is surrounded by a greyish semi-transparent or opaque zone infiltrating

the surrounding tissues, and often sending processes in various directions along the lines of the vessels for some distance. The organ in which it is situated is also, in many cases, the seat of general interstitial fibroid induration.

From the above description it will be seen that a gumma resembles tubercle in being a new growth of the type of granulation tissue, prone to early fatty degeneration, followed often by softening and elimination by suppuration. It differs from tubercle in being vascular during the whole stage of evolution, in its capability of being absorbed or of undergoing a development in part into fibrous tissue, in the toughness of its tissue, and in the absence of the characteristic tubercle nodule, with its giant cell, epithelioid cells and lymphoid corpuscles. Moreover, it is not inoculable on animals, nor has it been proved to contain any specific organism. Lustgarten has described a bacillus, but the observation requires confirmation.

Clinically in those parts in which a gumma comes under the observation of the Surgeon, it forms an indolent tumour of slow growth, often accompanied by a good deal of aching pain. If superficial, it slowly approaches the cutaneous surface, the skin becomes adherent, and then dusky red. The mass softens and fluctuates distinctly, and an opening forms from which some thin unhealthy pus escapes. This gradually increases in size by ulceration in many cases, till the whole reddened skin is destroyed. The tissue of the gumma is seen as an adherent, tough slough, like a piece of wet wash-leather, which slowly separates; the cavity becomes lined with healthy granulations, and heals without difficulty, leaving a deep cicatrix. If a bone be affected, a carious patch is left, sometimes complicated by the presence of sequestra of varying size. Small gummata, not more than one-quarter of an inch in diameter, may form in the cutis vera, and afterwards soften and run the same course as deeper and larger growths of the same kind. In this situation they form the skin disease known as *tubercular syphilide*. Gummata do not necessarily cause any enlargement of the neighbouring lymphatic glands, though this may occur when softening and suppuration are taking place.

Gummata will be further referred to in connexion with the organs in which they are found.

Gummata have occasionally been met with in an early stage of syphilis, and some authorities have maintained that the processes concerned in the formation of a gumma differ in no essential respect from those occurring in the induration round the primary sore and in the lymphatic glands. There is, however, one essential difference—the discharges from softening gummata are, so far as is known, not infective, consequently it seems probable that the specific virus of syphilis is not present in them. It has therefore been suggested that the changes in the vessels, the diffuse overgrowth of interstitial tissue of organs, and the formation of gummata, are not the direct effects of the virus, but are due to some modification of the mode of growth and nutrition of the tissues, impressed upon them by the poison while it was active in the system. The unsymmetrical character of the later eruptions would indicate that they are not dependent on an active virus circulating in the blood-stream. At present we have not sufficient knowledge of the nature of the virus of syphilis, or of its mode of action, to render these speculations of any real value.

PROGNOSIS.—The severity and form of the manifestations which follow contagion vary greatly. Diday states that in 93 cases treated by him without

specifics, 7 suffered only from a single eruption on the skin, and after that showed no further signs of the disease; in 53 the disease lasted from ten to eleven months, with eruption on the skin and mucous membranes, occurring irregularly with repeated relapses; 29 suffered from severe cutaneous eruptions, periostitis, iritis, &c., the average duration of the disease being twenty months; and in 4 only did the disease assume a grave form with early appearance of tertiary symptoms. Berkeley Hill considers that these statistics form a valuable index of the natural course of syphilis.

The **Circumstances influencing the Progress** of the disease are chiefly the following :—

Age.—Other things being equal, the disease runs the mildest course in young adults. Infants suffer more severely, and after middle life syphilis is very apt to prove intractable. According to some authorities, it is practically incurable if contracted after forty, the patient being constantly troubled by relapses for the remainder of his life.

Sex.—Females are apt to suffer severely, because, owing to the more concealed situation of the primary sore, they often do not come under treatment till the secondary symptoms are fully developed. Pregnancy usually aggravates the course of the disease.

Personal Habits and Surroundings have a considerable influence on the course of syphilis. The disease is seen in its worst forms amongst those who suffer from insufficient food, clothing and washing, and are addicted to alcoholic excesses. In a young adult of sound constitution, who leads a healthy and steady life, with plenty of out-door exercise, syphilis is very rarely followed by any of its graver consequences, and usually ceases to give rise to any symptoms in about one year.

The *state of the patient's health* also determines to a great extent the kind of attack he will undergo. In scrofulous subjects the disease usually runs a severe course, and tertiary ulcerations are very prone to occur. In gouty subjects the skin eruptions are very apt to relapse, and periostitis is common. Rheumatism also is said to render the patient prone to inflammations of bones and to iritis during the progress of syphilis. Chronic renal disease is always a most serious complication, partly no doubt because patients so affected do not bear the mercurial treatment well.

After the symptoms of the disease have subsided, they may again be called into activity by any cause which seriously impairs the general health. It is remarkable for how long a time the syphilitic poison will lie dormant in the constitution without producing any local manifestation of its existence, until this is developed under the influence of a broken state of health. I have had under my care an extremely severe case of constitutional syphilis, in which twelve years elapsed after the occurrence of the primary disease, during the whole of which time no secondary affection was observed until the patient's health gave way from other causes. I have also had under my care an officer, in whom a very severe form of constitutional syphilis occurred, for the first time, after salivation for hepatic disease, five years after the primary sore had been contracted—no constitutional manifestation having attracted the patient's attention in the meanwhile. Not only does a state of ill-health hasten the occurrence of secondary syphilis, but neglect or indifference to its existence may keep it up indefinitely.

That the *treatment of the primary* sore exercises considerable influence can-

not be doubted. The severity of the course of syphilis is, I believe, materially lessened by a mercurial course, if that course be properly conducted.

The question as to there being any connexion between the *nature of the primary sore* and the character of the consecutive constitutional affection has been much discussed, and very different opinions have been expressed. The generally received opinion at the present time is, that no safe conclusions as to the future course of the disease can be drawn from the appearance of the primary sore. Tertiary symptoms are, in fact, frequently met with in patients who have not a trace of a scar left by the primary sore, and sometimes even in those in whom the initial manifestation has been so slight as to escape notice.

The *character of the secondary symptoms* seems to give a much more valuable indication of the probable course of the disease. A copious early squamous or papular eruption is believed to indicate a quick course, terminating at an early period. Those cases in which the skin disease persists long and frequently relapses have been observed to suffer but rarely from visceral affections. It is a remarkable fact, noted by Lancereaux, Berkeley Hill, and Wilks, that a large proportion of those who suffer from visceral syphilis have passed through a very mild secondary stage, often so wanting in symptoms as to be scarcely recognizable. This fact is particularly noticeable in tertiary syphiloma of the nervous system. It must not be concluded, however, from these facts that severe tertiary symptoms must necessarily follow a mild secondary stage. In the great majority of cases a mild secondary stage, when it occurs, forms the end of the disease. Berkeley Hill states, that marked general glandular enlargement is a bad sign, being usually accompanied by anæmia and debility.

As a probable explanation of at least some cases in which severe tertiary symptoms follow a slightly marked primary and secondary stage, it must be remembered that such cases are very likely to have been imperfectly treated. This explanation is undoubtedly true of some cases in which a patient with tertiary symptoms is altogether unaware of ever having had a primary sore.

Death from syphilis, directly, during its secondary stage, is practically unknown. The disease kills more often by its tertiary manifestations, such as the development of gummata in the central nervous system or liver. Gowers is of the opinion that locomotor ataxy is most common in patients who have suffered from constitutional syphilis. Many aneurisms are believed to be due to syphilitic changes in the vessels. The proportion of cases, however, in which syphilis even indirectly shortens life is so small that it is not considered necessary to make any addition to the premium charged for life insurance because a patient has passed through an attack of syphilis, unless some definite tertiary symptoms are present.

Duration of Syphilis.—It is extremely difficult to say when syphilis can be eradicated from the system; and indeed it is a question whether it may not impress the constitution in a peculiar way, modifying certain processes during the rest of life, as we know to be the case in other specific diseases, such as cow-pox or scarlet fever. Certain it is that, if neglected or improperly treated, it may affect the system for an indefinite time, declaring its existence by exciting and modifying various local inflammations years after the original absorption of the poison. It is tolerably clear thata person who has once had the usual course of syphilis very rarely has it a second time, though he contract a fresh chancre. Exceptions to this rule are, however, occasionally

met with. But such cases are exceedingly rare, and occur only after an interval of some years has elapsed between the two attacks. Hutchinson has related a very interesting example of this kind in a medical student, who also suffered from two attacks of small-pox. Daily experience shows that in many constitutions syphilis cannot be eradicated, and that in most others, when once it has occurred, it is apt, even when apparently cured, to modify certain cutaneous and other affections in a remarkable manner, after a lapse of many years; showing clearly that, if the poison no longer exists in the system, the constitution has received a peculiar impress from it, which it is long in losing.

TREATMENT.—The **treatment of the primary stage** of the disease is local and constitutional.

Local Treatment, which is all that is required in the simple chancre, is of comparatively little importance in the true syphilitic sore, the causes of the local manifestation being beyond the reach of any direct application. If the initial manifestation assumes the form of the desquamating papule every effort must be made to prevent its ulcerating by the application of some simple non-irritating substance, such as vaseline, to protect it from irritating secretions and friction. Attention to cleanliness by frequent washing is also essential. If an indurated sore forms, iodoform, which is of such singular benefit in the simple chancre, will be found of little use. Attention to cleanliness, the avoidance of irritating dressings, and the application of a piece of lint soaked in black wash will be found in most cases to be all that is necessary. Black wash sometimes proves irritating; a weak lead lotion, made by adding 5 minims of liquor plumbi diacetatis to an ounce of water, may then be used. Caustics are always injurious. It has been recommended by Ausspitz and others to excise the sore—on the theory that the virus may be still localized at the seat of infection, and that by removing the initial manifestation the further progress of the disease may be arrested. Experience has shown that excision does not produce the desired effect, a fact which confirms the view that the induration of the sore is in fact the first sign of constitutional infection. Should the sore assume a phagedænic form, it must be treated as already described.

The **Constitutional Treatment** of primary syphilis need not be separated from that of the secondary stage, as the same remedies that favour the healing of the initial manifestation exercise a beneficial influence on the secondary affections. The constitutional treatment of syphilis has undergone various changes according to the prevailing doctrine of the day. It had been decided by the Surgeons of the last and the early part of this century, that mercury acted as a specific against the syphilitic poison. This doctrine was so firmly established, that Hunter, and many of the great Surgeons of his school, looked on the curability of a sore without mercury as a proof that it was not syphilitic.

About the commencement of this century, however, it was found by observations of the Army Surgeons, amongst whom Rose took a principal share in the inquiry, that many forms of venereal ulcer (no distinction being then drawn between the local non-infecting sores and the ulcers which resulted from the contagion of the constitutional disease) were curable without the necessity of administering mercury, or indeed of having recourse to any specific treatment whatever. These observations, which were chiefly made in Spain and Portugal during the Peninsular War, led to the introduction of

the *non-mercurial* or *simple* treatment, as it is termed—a mode of practice that obtained great favour and was extensively tried. On the definite separation of the simple non-infecting chancre from the true syphilitic sore, however, a reaction took place in the minds of most Surgeons, and mercury is now almost invariably employed in the treatment of the latter, and is administered more moderately and scientifically, and consequently more successfully, than before.

The arguments in favour of the non-mercurial plan of treatment were briefly these: that the constitution of the patient is saved the introduction of a mineral which occasionally acts injuriously, and which, as the disease can be cured without it, may at all events be looked upon as unnecessary; that secondary affections less frequently follow this plan than they do the administration of mercury; and, lastly, that those distressing cases of constitutional syphilis which are common after mercurial courses, and which are said to depend upon a peculiar combination of the syphilitic poison with the mineral in the system, are never met with in persons who have undergone the simple treatment. These arguments, however, on closer examination and further experience, have been proved to be not quite so conclusive as the supporters of the simple treatment appear to believe. Before the simple sore was clearly distinguished from the initial manifestation of syphilis, the early healing of the chancre and the absence of secondary symptoms after it were taken as evidence of the efficacy of the non-mercurial treatment of syphilis. Now that the two forms of sore are clearly separated from each other this fact has of course no bearing on the question, and experience has undoubtedly shown that although the true indurated sore will heal in time without the administration of mercury, yet the process of cicatrization is slow and often imperfect, the scar readily breaking down again for some time after apparent healing; whereas if mercury be given the healing is rapid and permanent. This is, however, but a small part of the question. It is a most serious error to confound the healing of the primary sore with the cure of syphilis. The test of the relative value of the two plans of treatment must depend rather on the influence they have over the course of syphilis, and on the character that the symptoms assume under one or other of these methods, than on the mere skinning over of the ulcer. I cannot agree with the statement that secondary symptoms are less frequent after the simple than after the mercurial treatment. In fact, since the separation of the simple chancre from the true syphilitic sore the fact has become clearly recognised that no mode of treatment can prevent the appearance of secondary symptoms; mercury may diminish their severity or delay their appearance, but constitutional syphilis must unavoidably follow the indurated sore, though sometimes the symptoms may be so slight as almost to escape detection.

I have seen the non-mercurial plan of treatment very extensively employed at University College Hospital; indeed, it was formerly almost invariably practised there, more particularly in the syphilitic cases occurring among the out-patients under Morton, who strongly advocated it; and I have had repeated occasion to observe the frequency with which it was followed by secondary symptoms. In private practice, also, I have had considerable opportunities of comparing the two methods, and I can safely say that I have seen the simple treatment more frequently followed by severe secondary symptoms than the mercurial plan has been when properly and judiciously employed. The supporters of the non-mercurial treatment, when obliged to

admit the great frequency with which it is followed by secondary symptoms, argue that these are less severe after the simple than after the mercurial plan; and they state—as it appears to me, without one atom of evidence to support their statement—that mercury and syphilis together form a sort of poisonous compound in the system, which produces the most destructive forms of constitutional syphilis. It is doubtless true that, after an ill-regulated mercurial course, constitutional syphilis of a very severe character may occasionally appear; but this seems to me to be rather owing to mercury having been improperly administered in constitutions that will not bear it, and in which, by the induction of a cachectic condition of the system, it favours the occurrence of some of the more severe forms of secondary syphilis, in the same way that any other lowering plan of treatment, or simple debility, might occasion them, but without the exercise of any specifically injurious influence. Some of the worst forms of constitutional syphilis that I have seen occurred in patients to whom no mercury had been administered, but in whom the syphilitic virus had been allowed to exercise its influence unchecked, save by the so-called simple treatment. Thus I have seen the body covered with immense ecthymatous crusts and sores in one case, rupial ulcers with destruction of the nose and palate in another, the worst kind of syphilitic cachexy with the tuberculo-pustular syphilide in a third, and extensive disease of the cranial bones and the clavicle in a fourth.

But, though I cannot admit that the supporters of the non-mercurial treatment of syphilis have brought forward any proof of its superiority over the mercurial plan, and though my own experience has taught me that secondary symptoms occur after it with no less severity than they do when mercury is judiciously administered, yet I am quite ready to allow that there are certain conditions of syphilis in which the non-mercurial treatment alone is admissible, the state of the constitution or the disease being such that mercury cannot be given in any form. In these cases such a treatment must be adopted, in accordance with ordinary medical principles, as will tend to improve the general condition. It is, indeed, especially in individuals who are suffering from visceral disease of some kind, especially Bright's disease, or whose powers have been broken by habitual dissipation, that this plan of treatment should be adopted. So also in those who, from the nature of their occupations, are subjected to much exposure to wet and cold, a mercurial course cannot be properly or safely administered, and the simple treatment is most advisable. In all other cases I am certainly of opinion that mercury ought to be administered; and this opinion appears to be entertained by the most experienced Surgeons of the day in this country and abroad.

The first question in connexion with the employment of mercury in syphilis has reference to the principle on which this remedy is administered. Whether mercury exercises a specific action over the poison of syphilis or not, has been much discussed, and is difficult of proof. I certainly think that it does act as a specific in syphilis, but that this action is much influenced by the condition of the system, the habits of the patient, and the mode of administering the remedy; these conditions under certain circumstances tending to counteract or otherwise to interfere with its operation. That mercury is antagonistic to the syphilitic poison, appears evident from the fact that in some instances hard sores will not heal unless it be given internally; from its influence in speedily curing infantile syphilis and preventing after-

manifestations; and from the fact that, when properly administered *in healthy constitutions*, it may almost to a certainty be expected to dissipate the various symptoms of constitutional syphilis. When it fails, as it doubtless does in many cases, to prevent severe constitutional symptoms, the failure may usually be traced either to want of care in the administration of the medicine, or to the existence of an impaired state of the patient's health. The essential practical point in the treatment of primary syphilis by mercury is to keep the patient under a prolonged and mild course, rather than a short and active one.

Administration of Mercury in Syphilis.—In discussing this question the following points require consideration :—1. The cases in which mercury is inadmissible. 2. Cases in which it is required. 3. The effects of mercury and the degree to which its use should be pushed in treatment. 4. Its effect in different stages of the disease 5. The time during which its use should be continued. 6. The mode of administration. 7. The general management of the patient during the time he is taking the drug.

1. *Cases in which mercury is inadmissible.*—Mercury is especially dangerous in all forms of Bright's disease, so that it is well, if there be any suspicion of an unhealthy state of the kidneys, to examine the urine for albumen before commencing to give the drug. It is not well borne by those also who are exhausted by habits of dissipation, by insufficient food, or by bad hygienic surroundings. Lastly, some patients are peculiarly intolerant of mercury, apparently from some idiosyncrasy, and in these it may be impossible to give it with safety.

2. *Cases in which mercury is required.*—There is no doubt that the natural tendency of syphilis is to spontaneous recovery; this has been clearly proved by the effects of the non-mercurial treatment. It is equally certain, however, that mercury shortens the stages and lessens the severity of the disease, and that if carefully administered, it cannot do any harm. The administration of mercury is therefore advisable in every case of syphilis in which its use is not contra-indicated by one of the conditions above mentioned. As age increases, its use becomes more essential, for, as before stated, the disease becomes more obstinate in proportion to the age of the patient at the time of infection. In patients of the scrofulous diathesis, or in those suffering from active tuberculous disease, mercury must be administered with great caution, but its use is not contra-indicated.

3. *The general effects of mercury, and the degree to which it should be pushed in treatment.*—The observations of Liégeois, Hughes Bennett, and Keyes, show that mercury administered to a healthy subject in very small doses acts as a tonic. Under its influence the red corpuscles increase in number, and in animals a gain in weight has been noted. In larger doses it diminishes the red corpuscles. In syphilis, in which the red corpuscles are diminished in number, it causes an increase if administered in moderate doses. All forms of mercury administered by the mouth tend to act upon the bowels, and unless this tendency be checked, the desired alterative effect is not easily produced. The most marked sign of the action of the mercury is the effect upon the gums and mouth. The first sign that the drug is affecting the constitution is the appearance of a red line along the gums, close to the teeth; there is at the same time a slight sense of tenderness on biting any hard substance. In the present day the administration of mercury is not pushed beyond this point, and in the primary stage of syphilis, it is not even necessary in most cases to carry it so far before its good effects are apparent on the sore. Should the

drug be pushed further, either intentionally or accidentally, the swelling increases; the gums become soft and spongy, and overhang the teeth; the tongue swells, so as to show the impression of the teeth along its sides, and it becomes covered with a thick fur. The breath is offensive, and there is an increased flow of saliva, and a metallic taste in the mouth. This condition of "*mercurial salivation*" was in former times regarded as the proper effect to be obtained by the administration of the drug. In the present day it is regarded as an evil to be carefully avoided. If the drug be pushed still further, the teeth may be loosened, and fall out; the gums and tongue may become ulcerated, and acute inflammation may take place in the salivary glands. Ulceration of the inner surface of the cheek opposite the molar teeth may occur. At the same time there may be considerable febrile disturbance. The effects produced by mercury vary greatly in different individuals, a dose which would salivate one patient producing no effect on another. In the administration it is necessary, therefore, in all cases, to begin with a small quantity which may be gradually increased till the patient's dose is ascertained. Before beginning the treatment it is very advisable that all tartar should be scaled from the teeth. When symptoms of salivation set in, the mercury must immediately be discontinued. A brisk saline purge may be given, and the mouth must be washed with a strong alum or chlorate of potash gargle (10 to 15 grs. to the ounce of water). Ten to twenty grains of chlorate of potash with five minims of tincture of belladonna may be given internally three times daily.

In the treatment of syphilis the effect upon the primary sore is often a useful guide in the administration of mercury. If, under the influence of a certain dose, the sore rapidly assumes a healthy appearance and begins to heal, it may be taken for granted that that quantity is sufficient to act beneficially on the patient, and it may be adhered to during the whole course, unless special circumstances require an increase. It is better in all cases to be guided rather by the effect on the disease than by the effect on the gums. Swollen gums show that the limit of safety has been reached; if the symptoms are relieved without affecting the mouth, so much the better. There is no evidence that any tolerance of the drug is acquired by its prolonged administration.

4. *The effects of mercury in the different stages of syphilis.*—The effect of the drug on the primary sore is almost invariably very distinctly marked. The hardness round the sore becomes less intense and less sharply defined. The smooth pale surface becomes of a healthy red colour, granulations spring up, often of a florid tint, and bleeding readily; the thin serous discharge, characteristic of the typical hard sore, is replaced by pus, and by the end of a week or ten days the indurated chancre has assumed the appearance of a healthy granulating sore. As these changes take place, the sore usually becomes more tender and painful, and the patient may become alarmed at what to him seems a change for the worse. The induration at the base of the sore is often not completely absorbed for many weeks after the surface has been covered by new epithelium. Simultaneously with the softening of the induration, the glands in the groin become smaller, but they do not, as a rule, reach their normal size and consistence till long after the sore is healed.

The influence of mercury is not, in all cases, so unmistakeable in the secondary stage; but, in most cases, it is evident enough. The rashes fade or diminish in abundance, or may even be entirely prevented, and the sore throat subsides under the influence of the drug. It may be necessary, however, to push the

administration till the gums are distinctly affected before the effect is produced. In the tertiary stage its effect is far less certain, and the state of the patient's health is frequently such as to contra-indicate its administration. As a rule, it should not be given unless other means have failed, when it will sometimes be found to produce excellent effects if carefully administered.

5. *The time during which mercury should be continued.*—The administration of mercury should commence as soon as the nature of the disease is recognized, and be steadily continued while the secondary symptoms are making their appearance. Even if no secondary signs appear, it is better to continue the administration uninterruptedly for from four to six months, and then with occasional intervals to the end of a year. If no signs of the disease are present, its use may then be abandoned, and not renewed unless some fresh symptoms appear. The patient must be carefully watched, and if any signs of depression from the use of the drug become apparent, its use must at once be suspended. The occurrence of marked febrile disturbance immediately before the outbreak of the secondary symptoms is usually an indication for carefully pushing the drug.

6. *Mode of administration.*—Mercury may be administered in four ways: (*a.*) by the mouth; (*b.*) by inunction; (*c.*) by subcutaneous injection; or (*d.*) by fumigation.

(*a.*) *By the mouth.*—This, being the most convenient method, is usually adopted. As mercurial preparations are mostly purgative, it is necessary, in most cases, to add a small quantity of opium, to prevent this action. In the treatment of any given case, it is necessary to ascertain what preparation has least tendency to purge the patient, what amount of opium is required just to neutralize the purgative tendency without causing constipation or headache, and what dose is required to produce the desired effect on the disease. All these points can be ascertained only by observation of the particular case. The form that will be found most generally useful is the following: ℞, grey powder, gr. j.; Dover's powder, gr. j.; extract of gentian, q. s. to make a pill. The patient may begin with three pills a day for three days; if they give rise to no effects, either beneficial or the reverse, the dose may be increased to four, and after a few days to five, if necessary. Six are very rarely required. If the pill purges, the Dover's powder may be increased; if it constipates it must be diminished. A few variations usually succeed in hitting the exact proportion and dose suited to the case, and the prescription may then remain unchanged for weeks or even months. The ordinary blue pill is of the same strength as the grey powder, and may be given instead of it, if preferred; but it is slightly more apt to purge. It may be first tried alone, or with an equal quantity of extract of gentian, in grain doses, three, four, or five times a day. If necessary, powdered opium or Dover's powder is added. By patients very insusceptible to the drug, as much as ten grains a day of blue pill can sometimes be taken. If these preparations do not suit the patient, the green iodide of mercury, in doses commencing at half a grain, and gradually increased to a grain, three times a day, may be employed. It should be made into a pill with extract of gentian, and, if necessary, a sixth to a third of a grain of extract of opium may be added. The only objection to this preparation is that it may decompose, the red iodide and free mercury being formed; it then acts much more powerfully, and may salivate. The perchloride of mercury, or the bicyanide may sometimes be tried if the foregoing

fail. They are given in doses of from $\frac{1}{16}$ to $\frac{1}{10}$ of a grain, made up into pills with sugar of milk and varnished. Calomel is never to be recommended, being too irritating. Mercury can also be administered in a mixture, if the pills do not suit. In debilitated constitutions, and in the tertiary stage of the disease, the perchloride in doses of from $\frac{1}{16}$ to $\frac{1}{8}$ of a grain may be given, with compound tincture and infusion or decoction of cinchona. To this are sometimes advantageously added a few grains of iodide of potassium, by which the perchloride is converted into the red iodide of mercury, which is held in solution by the excess of the potassic iodide. Plummer's pill, in five grain doses, taken two or three times a day, is very useful in the syphilides.

In many cases iron may advantageously be combined with mercury. For this purpose a pill having the following composition may be given three times a day: Grey powder, gr. j.; reduced iron, gr. j.; sulphate of quinine, gr. j.; powdered opium, gr. $\frac{1}{4}$; extract of gentian, gr. j.

(*b.*) *Inunction.*—This may conveniently be practised when it is desired to put the patient rapidly under the influence of mercury or when the bowels are so irritable that the drug, if given by the mouth, invariably purges the patient. It is best done by rubbing a scruple to a drachm of mercurial ointment into the inside of each thigh or arm or in the axilla before going to bed. Hill recommended that the ointment should be made up with lanolin and that a drachm of olive oil should be added to each ounce of the ointment. The skin should be well washed before the mercury is rubbed in. After the inunction the patient should put on flannel clothes next his skin to encourage sweating and go to bed. In the morning he should take a hot bath. The inunction must be repeated daily till some effect is produced, and it is best not to rub the ointment into the same part on two consecutive days. It must be borne in mind that the orifices of the sweat-glands and hair-follicles become filled with the ointment; so that, should salivation commence, it is not easy at once to arrest the absorption of the mercury. During the treatment the patient should use an alum mouth-wash. The use of the hot bath every morning diminishes the risk of the absorption of an undue amount.

(*c.*) *Subcutaneous injection* of mercury has been employed on the Continent by Lewin and other Surgeons, and in this country by Walker of Peterborough, Bloxam, and others. Sigmund of Vienna believed it to be most useful in those forms of the disease affecting the more superficial structures and the osseous, muscular, and fibrous tissues. Hill, who extensively tried this mode of administration, was of opinion that it should be reserved for those rare cases in which mercury cannot be taken in the more ordinary ways.

The best preparation for injection is sal alembroth, the double chloride of mercury and ammonium; one-third of a grain should be dissolved in ten drops of water and injected on every fifth day. The injections should be made into the muscles of the back or buttock. Sal alembroth injections are very rarely followed by abscess, which is not uncommon after the injection of the perchloride, red iodide, and the so-called "grey oil" (composed of mercury, lanolin, and olive oil), which have all been employed. Another preparation which has been recommended for injection is the sozoiodolate of mercury; one-third of a grain is dissolved with two-thirds of a grain of iodide of sodium in ten minims of water. This may be given as an intramuscular injection every fifth or seventh day.

(*d.*) *Mercurial fumigation.*—In some cases of syphilis in which the patient

cannot tolerate the drug by the mouth, mercury may conveniently be administered by fumigation. This plan of treatment, which has been especially recommended by Langston Parker and H. Lee, consists of a combination of vapour-bathing and of mercurial fumigation. The baths may also be associated with appropriate internal treatment. Fumigation is thus carried out: the patient is seated naked on a wood-bottomed chair and is covered with a cloak made of some thick woollen material reaching to the floor and fastened round the neck. It is fitted with a cane hoop to keep it from touching the body. A lamp consisting of a circular trough to contain about one ounce of water, and a central plate for the mercurial preparation, is used for producing the vapour. The water must be made to boil thoroughly before the mercury is put on the plate. It is then immediately put under the chair, and thus the patient's body will be steamed for a minute or two before the mercury begins to volatilize. The best form of apparatus is that known as Lee's lamp, but in the absence of all special apparatus fumigation can very easily be carried out by means of two spirit lamps and two metal vessels, one for the water and one for the mercury, the patient being covered with a thick blanket. Various forms of mercury have been used, but the two best seem to be the bisulphuret as recommended by Langston Parker, in doses of from one to two drachms at each bath, and calomel, which has been extensively used by Henry Lee in doses of from twenty to thirty grains. Whatever form of apparatus be used, after about twenty minutes, when the whole of the mercury will have been volatilized, the patient gets into bed wearing the cloak or blanket. He must not be left alone during the bath, as he may become faint. If perspiration does not begin at once, a little weak hot tea may be given to encourage it.

7. *General management of a patient during a course of mercury.*—Regular hours, sufficient exercise in the open air, abundant simple food, and the avoidance of alcoholic or other excesses are of equal importance in the management of a case of syphilis as the administration of mercury. While the patient is under the influence of mercury the skin should be kept in a healthy state by baths. In summer there is no objection to a morning cold bath, but in winter some warm water should be added to prevent a chill. The patient should wear flannel next his skin both in summer and winter. A chill during a course of mercury may cause a violent attack of diarrhœa, sometimes accompanied by much griping pain and vomiting. The diet should be plain, and anything likely to irritate the bowels, as excess of fresh fruit, green vegetables, or made dishes, should be avoided. Beer should be prohibited, as it is apt to cause purging. Claret is perhaps the best alcoholic drink that can be taken. All these things must, however, be left, to a certain extent, to the common sense and experience of the patient. Exercise is of the greatest value, but should not be carried to the extent of fatigue.

Other Drugs used in the Treatment of Syphilis.—In the primary and early secondary stages of syphilis no drug but mercury can be said to exert any real influence on the disease; but in the later secondary and tertiary stages the *preparations of iodine* produce effects not less clearly marked. Iodine is supposed to be a specific in a minor degree to mercury. It has also been proved that in patients who have undergone a course of mercurial treatment iodine liberates the mercury which may have become stored up in the body, the mercury re-appearing in the urine and other secretions on the administration of the drug. The effects of iodine are not, however, due to

this, for they are well marked in patients who have never taken any mercury during the early stages. The preparations of iodine are most useful in the various forms of visceral-syphilis, in syphilitic disease of the nervous centres, and in treatment of gummata wherever they may be situated. Useful as iodide of potassium is, however, I do not believe that syphilis can be eradicated from the system by means of it; indeed, I cannot call to mind a single case presenting marked tertiary symptoms which has been permanently relieved without the administration of mercury.

Iodine is commonly administered, as *iodide of potassium*, in doses of from five to twenty or even thirty grains. It is often combined with some bitter infusion, but there is no advantage in this unless the patient requires a tonic. A most convenient mode of giving iodide of potassium is the following: Put one ounce of the iodide into a two-ounce bottle and fill it up with water; let the patient take eight drops of the solution in a wineglass of water or in milk three times a day, and gradually increase the dose by two drops every two or three days till he finds by the symptoms of iodism that he has reached his limit. An intelligent patient will soon learn to regulate his dose without the necessity of constantly applying to the Surgeon. The addition of a few drops of aromatic spirit of ammonia is said to make the iodide more active. If the patient is anæmic it may be taken in conjunction with the iodide of iron.

Iodide of Ammonium can sometimes be taken by patients who cannot tolerate the potassic iodide. It may be given in doses of ten grains and upwards, and two or three grains of carbonate of ammonia must be added to each dose to prevent the decomposition of the iodide. It is probably the least depressing of the iodides.

Iodide of Sodium has also been recommended in doses of five grains and upwards. It is said to be less depressing than the potassium salt.

In whatever way iodine is administered, if pushed beyond a certain point it gives rise to toxic symptoms known as "*iodism*." The amount of the drug required to produce these effects varies with every case. The symptoms resemble a bad cold in the head; there are redness of the eyes, running at the nose, and frontal headache. Every patient who is taking the iodides must be warned of these symptoms, and be told to reduce the dose immediately they appear. In severe cases swelling of the tongue and lips, and even ulceration of the pharynx, may occur. Prolonged administration of iodides not unfrequently gives rise to a pustular eruption resembling acne, or more rarely to large pustules on an indurated base, which dry up, leaving a scab behind them. In other cases an eruption consisting of large papules and plaques may occur about the neck and face. Purpura and albuminuria have also been attributed to its influence. It must be remembered that children do not bear the iodides well.

The *Sulphides of Calcium and Potassium* are said to form most useful adjuvants to mercury, promoting its action and preventing its accumulation in the system. How much real value they possess is still uncertain. The Aix-la-Chapelle treatment, which has obtained great celebrity for the cure of syphilis, consists of the administration of mercury by inunction, combined with the use of the natural hot sulphur waters, both for bathing and drinking. The chief advantage derived in most cases from a visit to Aix-la-Chapelle arises from the fact that the patient, having little else to do, and being carefully looked

after by the physicians and the rubbers, and regularly dieted in his hotel, cannot neglect the treatment as he is too apt to do at home. It is for rich patients who are not taking proper care of themselves that a visit to the baths is to be recommended. A course lasts from six to seven weeks.

Sarsaparilla formerly enjoyed a great reputation in the treatment of syphilis, but at the present time it is little used. It may, however, be given in the late secondary or tertiary stage, especially if the patient have fallen into a cachectic state, having lost flesh, colour, appetite, and spirits. In this condition of the system dilute nitro-hydrochloric acid, in doses of fifteen to twenty minims, with half an ounce of the liquid extract of sarsaparilla in four ounces of water, may be taken three times a day.

Cod-liver Oil is often of great use when there has been considerable loss of flesh. It may be given at the same time as the iodides of potassium or iron.

Bitter Tonics and the *Preparations of Iron* are frequently useful in the tertiary stage. They are given on general principles after or in the intervals of specific treatment.

LOCAL SECONDARY AND TERTIARY MANIFESTATIONS OF SYPHILIS.

LOCAL SECONDARY AFFECTIONS.—We shall next proceed to describe the character and treatment of the different *local forms* in which constitutional syphilis manifests itself, and shall consider them as affecting the skin; the mucous membranes of the mouth, nose, tongue, palate, and larynx; the eye, bones, testes, muscles, viscera, and nervous system.

1. **Syphilitic Affections of the Skin.**—Syphilo-dermata or Syphilides present various modifications of appearance, corresponding closely to the different groups of simple cutaneous diseases; thus we find exanthematous, papular, squamous, vesicular, pustular, and tubercular syphilitic affections of the skin, with various ulcers and growths. These differ from the corresponding simple cutaneous diseases, in their redness being more dusky or coppery, in leaving stains of a brownish or purplish hue, and in their giving rise to no itching or other painful sensations. The general pathology of these affections has already been described (p. 1130).

Besides this, syphilis may modify materially the general character of the cuticle, causing it to assume a yellow or earthy tint, and to be rough or powdery.

Syphilitic skin diseases arrange themselves under the following groups:—

Syphilitic *Roseola* consists of blotches of a reddish-brown or coppery tint, becoming more distinct as the redness declines; they vary in size from small circular spots to large and diffused patches, and are usually first observed about the abdomen. Syphilitic roseola is the most constant, and the earliest of all the syphilitic eruptions, often appearing before the primary sore is healed. It usually appears about seven or eight weeks after infection, and may last from a few days to two or three weeks. It is very frequently accompanied by an erythematous redness of the throat.

The *Squamous* syphilide, or as it is often called *syphilitic psoriasis*, occurs in small patches of an irregular shape, of a dusky red colour, sometimes assuming a coppery tint, covered with thin filmy scales. In many instances, however, the patches are quite smooth, and have a glazed and almost shining look. They are usually situated on the inside of the arms and thighs,

often on the scrotum and penis, even occurring on the glans. They also frequently appear on the palms and soles, where deep fissures and cracks are met with. In moist parts, as in the folds of the groin in fat people, at the margin of the anus or between the toes, they become more elevated and merge gradually into the "mucous tubercle" or flat condyloma to be described hereafter. About the lips the squamous syphilide gives rise to deep and troublesome fissures. It differs from psoriasis in its showing a preference for the softer and moister parts of the skin, whereas psoriasis is most abundant on the drier parts, as on the back of the elbow or the front of the knee. The scales also are less abundant. Squamous syphilide forms the most common eruption, after the roseola, during the first year of syphilis. It is often associated with ulceration of the tonsils and iritis, and not uncommonly with periostitis.

Papular Syphilide, or *Syphilitic lichen*, consists of small hard elevations, at first red, but afterwards becoming dusky or brownish. There is some slight branny desquamation on the surface. They are most common on the forehead and shoulders, and last about three weeks before fading. A rare eruption is the *Follicular* syphilide in which small papules form around the hairs.

The *Vesicular* syphilide is of very rare occurrence. The vesicles vary in size from a pin's head to a pea. They soon dry, and when the scales so formed separate a coppery red patch is left beneath. In one case which fell under my observation, the rash appeared in the form of clusters of small pointed vesicles, which on drying left grey or brownish crusts and coppery marks. Many varieties have been described and named according to the non-syphilitic skin affections they resemble, as eczematous, herpetiform, varioliform, and varicelliform.

Pustular syphilides occur somewhat rarely in the early stages, but are more common later on. The early pustular syphilide commences as a small vesicle which soon becomes pustular. It then dries into a crust, which falls off, leaving an elevated coppery spot beneath. It is merely an aggravation of the vesicular eruption, and leaves no ulceration or scar behind it. Larger pustules forming slowly with a dusky-red or coppery areola are met with in cachectic subjects, forming the eruption known as *syphilitic ecthyma*. The pustules dry, leaving a dark flat scab, which after a time falls off, leaving an ulcer which heals slowly. Ecthyma is most common on the limbs.

In the late secondary or in the tertiary stage in debilitated subjects, the affection known as *rupia* is not uncommon. It seldom occurs before the end of the first year, and may be met with as long as the syphilitic taint persists. Rupia commences as a bleb which rapidly becomes converted into a large pustule, surrounded by a wide brown or coppery areola. It soon dries into a circular dark brown or even black scab. Beneath this ulceration takes place, and the crust increases in thickness from the drying of the discharge, while at the same time it extends at its circumference; it thus comes to assume a conical form, and somewhat resembles a limpet-shell in appearance. After its separation a troublesome ulcer of a circular shape, often with a somewhat foul surface, is left, which may continue to spread slowly. This disease may appear on the face, but is especially common on the extremities. It is always indicative of grave constitutional debility.

Syphilitic *Tubercles* commonly occur as an advanced or tertiary symptom; they are in fact gummata of the cutis vera. They appear as hard, smooth

flat elevations of a reddish-brown or purplish colour, usually arranged in groups of single tubercles lying closely together. They are seated on the face or extremities, the skin covering the patella and the ala of the nose being common situations. They may be resolved by proper treatment, but have a great tendency to ulcerate and to be followed by slowly spreading serpiginous sores.

Subcutaneous syphilitic gummata, or, as they have been called, deep syphilitic tubercles, arise in the tertiary stage of syphilis as hard indolent masses in the subcutaneous tissue, usually accompanied by some slight aching pain or tenderness. They may vary in size from a pea to a walnut. They are of slow growth, but ultimately become adherent to the skin, which then assumes a dusky-purple tint. If unrelieved by treatment the gumma softens and the skin gives way over it, exposing the characteristic adherent slough resembling wet wash-leather. This slowly separates, leaving a deep cavity. Subcutaneous gummata may occur at any part of the body; common situations are the back of the thigh and the upper part of the arm.

Syphilitic *Boils* of a somewhat chronic character, but painful, and discharging a thin ichorous pus, with a core of shreddy areolar tissue, and leaving deep, irregular, and foul ulcers, are sometimes met with.

Syphilitic *Ulcers* are superficial and deep. The superficial ulcers arise from pustules, ecthyma, rupia, superficial tubercles, or boils. In some cases, especially on the leg, they arise like simple ulcers from some slight injury, but assume peculiar features in consequence of the syphilitic taint. Superficial syphilitic ulcers are usually characterized by their multiplicity, by their tendency to spread at one edge while healing at the other, and thus to assume a crescentic or serpiginous form, and by their unhealthy grey surface. They leave bluish or brownish cicatrices, often thin and smooth, and apt to break open again on slight irritation. The deep ulcers arise from softening gummata as above described.

The *Hair* during the first year of syphilis frequently becomes lustreless and dull, and comes out in large quantities, often so as to cause baldness—syphilitic alopecia. Occasionally it may separate in patches. The baldness is not permanent; in fact, it resembles the fall of the hair so often noticed in erysipelas and various fevers.

Diseases of the *Nails* are common. During the early stages the nails frequently become brittle and irregular in growth. A more serious affection is *Syphilitic Onychia*, which consists in a chronic inflammation of the matrix, with fœtid discharge from under the nail; the end of the affected digit is swollen, purple in colour, and intensely tender; the nail becomes black, more or less bent, and scales off, leaving a dirty ulcerated surface exposed beneath. One nail only is usually affected.

Ulceration between the Toes with excessively foul discharge and great swelling of the foot is not an uncommon condition in syphilis. It apparently arises from the formation of soft flat growths of the same character as the mucous tubercles at the anus, the ulceration being due to the irritating secretion between the toes and want of cleanliness. It is easily recognized, for it may be taken as a rule that all ulcerations between the toes are due either to syphilis or to scabies. The ordinary soft corn discharges no pus.

The *Treatment of Syphilitic affections of the Skin* must be conducted in accordance with the general principles already laid down. All the symmetrical

eruptions occurring in the early stages of the disease are best treated by the administration of mercury according to the rules already given. The tubercular eruptions and the squamous forms, when occurring after the first year, can often be relieved by iodide of potassium, especially if the patient has been treated with mercury in the earlier period. Donovan's solution is often of the greatest possible value, the disease rapidly disappearing under its use. The same plan is required in the management of syphilitic boils. In the pustular forms, syphilitic rupia and ecthyma, as the constitution is commonly shattered, a tonic plan of treatment is required in the first instance; after which the perchloride of mercury with tincture and decoction of cinchona, or sarsaparilla should be steadily administered. In these cases also much benefit will be derived from mercurial fumigation.

In most cases no *local treatment* is required for the squamous or papular eruptions, but should they occur on the face the patient is often anxious to hasten their disappearance. For this purpose dilute white precipitate ointment, or calomel made into a cream with olive-oil and lard, may be applied. Marshall recommends the application of a 10 per cent. solution of oleate of mercury with some morphia added. In all *ulcerating syphilides* iodoform, either applied pure or made into an ointment with vaseline, will be found most useful. In deep ulcerations iodide of starch ointment often produces a good effect. If these fail, yellow wash or perchloride of mercury in the strength of two grains to the ounce, diluted with water if it cause too much pain, will often arrest the spread of the ulceration and hasten its healing. If nothing else succeeds it may be necessary to cauterize the surface with fuming nitric acid or the acid nitrate of mercury. In syphilitic *alopecia* the internal administration of mercury has most influence in arresting the loss of hair; at the same time dilute white precipitate ointment may be rubbed into the scalp at night or a stimulating lotion applied. B. Hill recommended the following:—℞. Tincture of Cantharides, Solution of Ammonia, āā ℥ss.; Spirit of Rosemary, ℥i.; Glycerine, ℥ss.; Rose water to ℥viij. In *syphilitic onychia* the nail should be removed and iodoform applied. Black wash or yellow wash is sometimes useful. In *ulcerations between the toes* dilute white precipitate ointment, with a small quantity of extract of belladonna added, is useful, or the following dusting powder may be applied:—Calomel, ʒj.; oxide of zinc, ʒj.; starch, ʒij.

2. **Mucous Tubercles and Condylomata.**—*Mucous tubercles* are flat patches, seldom more than half an inch in diameter, slightly elevated, soft, and papillary on the surface (Fig. 404). They are situated in moist parts of the body, very commonly on muco-cutaneous surfaces, as the anus, labia, and angles of the mouth; they are also frequently met with on mucous surfaces, as on the tongue, tonsils, palate, and larynx, and exactly similar growths are found in any part of the skin that is kept moist by the natural secretions, and not properly cleaned, as between the scrotum and the thigh, in the fold of the groin in fat people, and between the toes. They are moistened by a good deal of mucous secretion when seated on mucous membranes, or by perspiration when on the skin. In the mouth and throat they are usually small and not so distinctly elevated, but rather like a thickened and opaque condition of the mucous membrane in these situations. At the anus they sometimes attain a considerable size, so as to project a quarter to half an inch above the surface, and it is then that they are commonly termed *condylomata*. They are frequently

mistaken by the patient for piles. They consist essentially of an overgrowth of the papillæ stimulated in part by the irritation of dirt or unhealthy secretions. They are common in conjunction with the squamous syphilide on the drier parts of the skin, and every gradation can sometimes be traced between a scaly patch to a mucous tubercle, according to the moisture of the part in which the patch is situated. They are met with most commonly during the first six months of the disease. They differ from the venereal warts already described (p. 1119), not only in their flatter form and less marked papillary structure, but in being dependent on a constitutional disease, and not on local causes solely, such as the irritation of discharges and want of cleanliness. The discharge with which they are moistened is intensely contagious, and it is from them, when situated in the mouth, that the disease is transmitted by kissing, or by means of drinking-vessels, or pipes, and from infants to their nurses. Their *Treatment* must be constitutional and local. The constitutional treatment is merely that of early syphilis. When seated at the anus or on the skin, they are best treated with the dusting power above-mentioned, and the use of boric acid baths. If this does not relieve them they may be rubbed with nitrate of silver or sulphate of copper. In the mouth the application of a solution of perchloride of mercury (gr. ij. to ℥i.), or of the solid nitrate of silver, is the best treatment. Not being pendulous, they do not, like simple venereal warts, require to be cut off.

Fig. 404.—Syphilitic Condyloma, showing enlarged papillæ covered with a thick layer of epithelium.

3. The **mucous membranes** of the *mouth, pharynx, and larynx* are commonly affected with secondary syphilitic eruptions, which assume the form of mucous tubercles, and of the exanthematous, squamous, and ulcerating syphilides; and in the later stages of the disease submucous gummata may form.

The *exanthematous* affection, corresponding to the roseolous form of cutaneous syphilis, and arising from the same cause and in the same constitution, principally affects the palate and throat. The *tubercular* variety corresponds to the squamous cutaneous eruptions, and is met with chiefly as flat, hard, and elevated tubercles in the interior of the mouth, nose, and throat. The *ulcerative* affection of the mucous membranes assumes a variety of forms, which will immediately be described, and occurs principally in the throat and nose. The exanthematous affection of the mucous membrane is usually an early sign of constitutional syphilis, frequently showing itself a few weeks after the primary occurrence of the disease. The other varieties belong to the more advanced secondary and tertiary periods. *Contractions* of various mucous canals often occur as the result of syphilitic affections, the narrowing being due to firm, fibrous bands, often excessively dense in structure. These

are often merely cicatricial, formed on the healing of syphilitic ulcerations. In other cases they seem out of all proportion to the extent of the destruction by ulceration, and would appear then to be due to diffuse fibroid induration of the submucous tissue, followed by contraction. They are most frequently met with in the rectum, vagina, and pharynx.

The syphilitic affections of the mucous membranes are most conveniently considered according as they affect distinct organs or parts of the body.

The *Lips* are commonly affected in persons labouring under squamous syphilide, with fissures or cracks usually somewhat indurated, and very painful in the movement of these parts. In the *Treatment*, the application of a pointed piece of nitrate of silver to the bottom of the crack will give the most effectual relief. The insides of the cheeks are not unfrequently affected in a similar manner, or become the seat of mucous tubercles, which must be treated as already described. In tertiary syphilis the lower lip is occasionally the seat of a diffuse gummatous infiltration.

The *Tongue* may be affected in various ways: when severely, its disease usually constitutes one of the tertiary manifestations of syphilis.

In the early period of the secondary stage of syphilis, small papules, similar to those on the skin, may appear. They are of little importance, and cause no inconvenience. During the second half of the first year of syphilis, and often at a later period, small superficial ulcers on the sides of the tongue, having an irregular or oval outline, and a grey surface, are not uncommon. They cause considerable discomfort. They are best treated by being touched twice a day with a solution of perchloride of mercury (gr. ij. to ℥j.). The surface must previously be dried with a handkerchief. Solid nitrate of silver is often as efficacious. Another form of late secondary manifestation on the tongue is a small fissure, or crack, at one side, surrounded by a zone of thickened epithelium, which gives the mucous membrane at the affected spot an opaque blue tint. These ulcers require the same treatment as those just described. Mucous tubercles are not uncommon on the tongue, but are less frequent than on the lips or cheek.

At a later period the dorsal surface of the tongue, usually only in its anterior half, undergoes a chronic change. The epithelium becomes opaque, white, and thickened, sometimes in patches, sometimes uniformly, and if the tongue be dried and then examined, it will be observed that the papillæ in the affected area have disappeared, the surface being almost smooth. The disease is a chronic inflammation affecting the corium of the mucous membrane, and the submucous tissue, with overgrowth of the epithelium covering the affected part. It has received various names, according to the appearance produced: when the surface is smooth, and bluish in tint, it is spoken of as the "*smooth tongue*," or *chronic superficial glossitis*; when the opacity is greater it has been called *psoriasis of the tongue*; and when the epithelium is heaped up so as to form scales, the term *ichthyosis linguæ* has been applied to it. These conditions most frequently result from syphilis, but cases are often met with in which no history of the disease can be obtained: they are permanent, the normal papillary condition of the tongue never being regained. Simple ulceration is not uncommon in the opaque patches, and in later life epithelioma frequently attacks the diseased mucous membrane. The treatment of this condition is very unsatisfactory. Perchloride of mercury lotions are often of use; they should be used in the strength of gr. ½ to gr. j.

to the ounce, and the patient should be directed to take a small quantity into the mouth and thoroughly pickle the tongue in it. Internally iodide of potassium produces most effect. If it fails, and the patient is in a state to stand it, a course of mercury may be tried.

The tongue is affected also in some cases by *diffuse overgrowth of its connective tissue*, occurring in patches and extending deeply into its substance from the mucous surface. More commonly it is the seat of *gummata*. These form, as a rule, in the muscular substance of the organ, and sometimes in the fibrous septum. They form indolent tumours, gradually reaching the mucous membrane, and implicating it. They run the usual course of gummata, and when they soften and open on the surface, leave deep foul ulcers, which may be mistaken for squamous carcinoma. The diagnosis of these affections, and their treatment, will be more fully considered under the diseases of the tongue.

The syphilitic diseases of the *Throat* are amongst the most common manifestations of constitutional syphilis, and frequently occur early. They present three chief forms, occurring in the early secondary, the later secondary, and the tertiary stages of the disease.

The early secondary eruption is a deep red exanthematous efflorescence of the soft palate and pillars of the fauces, either without ulceration or with but superficial abrasion. It occurs about the period of the invasion of the roseola and requires no special treatment. In the later secondary period, corresponding to that at which the squamous and papular eruptions appear on the skin, ulceration of the tonsils is very common. It appears first as white patches and mucous tubercles, in the centre of which the ulceration commences. The ulcers have sharply cut edges, often somewhat undermined. Superficial mucous patches may surround the ulcer, and extend on to the soft palate and pillars of the fauces. These ulcerations give little or no pain in most cases, and never cause any serious destruction of the mucous membrane. They require the ordinary treatment of constitutional syphilis, and locally may be occasionally touched with the perchloride of mercury solution (gr. ij to ℥j), or with nitrate of silver.

The tertiary ulcerations of the pharynx are far more serious. They seldom occur till three or more years after infection, and then only in patients in a debilitated state of health. The ulcers commence by a gummatous infiltration of the mucous membrane, similar in character to the tubercular syphilides of the skin. This breaks down, and a serpiginous ulceration starts from the affected spot, and may spread widely and rapidly. The ulcer has an irregular form and a foul grey surface, and may destroy in a few weeks a great part of the pillars of the fauces or of the soft palate. When the soft palate is destroyed, there is usually considerable difficulty in swallowing, and speech becomes altered. This form of ulceration occurs sometimes simultaneously with rupia on the skin, and requires the same constitutional treatment, the use of tonics being generally indicated. The best local application is a gargle, composed of corrosive sublimate, gr. iv; hydrochloric acid, ♏ viij; and water, ℥x. If the patient cannot gargle, or if the treatment has no effect, corrosive sublimate lotion (gr. ij to ℥j) may be carefully applied with a camel's hair pencil. Dusting the surface with iodoform often has a most excellent effect. It may be used in conjunction with the perchloride lotion or gargle. It is important to remember that gargles of the perchloride of

mercury cannot safely be used of a greater strength than a quarter to half a grain to the ounce of water; stronger preparations must be applied with a brush. In very obstinate cases cyanide of mercury is often useful; it may be used as a solution of the strength of 5 to 10 grains to the ounce, which must be applied with a brush by the Surgeon himself.

When the ulcers heal, the contraction of the cicatrices may give rise to *stenosis of the pharynx*. This may occur in three situations: 1st, between the top of the palate and the posterior wall of the pharynx, so as to cut off the nasal portion of the latter; 2ndly, between the soft palate, the walls of the pharynx and the tongue, and 3rdly, across between the pharynx and the posterior wall of the larynx. This stenosis is probably the result of ulceration of the opposite mucous surfaces; but it is often out of all proportion to the extent of the ulceration. It may gradually increase until the contraction becomes so great that swallowing is seriously impeded and breathing is carried on with difficulty.

In the second and third forms of the contraction it becomes necessary, in order to enable the patient to swallow and to breathe, to dilate the opening. This, if the stenosis be not too tight, may be done by simple dilatation by means of bougies. If very contracted, its edges should be carefully notched before dilatation. Before doing this it may be well to perform tracheotomy as a prophylactic measure, averting all danger of suffocation and spasmodic irritation during the manipulations in the pharynx.

Syphilitic ulcerations have been described as occurring also in the *œsophagus* and leading to stricture of that canal.

The mucous membrane of the *larynx* is frequently affected both in early and in advanced syphilis. The affections are similar to those of the fauces and pharynx. During the early exanthematous eruptions there may be some catarrh causing hoarseness and cough. Later on flat mucous tubercles may appear, but ulceration is rare. They disappear under treatment, leaving no ill effects behind. In the tertiary stage the most extensive ulceration, leading to destruction of the epiglottis and vocal cords, with necrosis of the cartilages, may take place. There is usually great thickening of the arytæno-epiglottidean folds, not unfrequently complicated by the formation of submucous gummata. If the patient recover, the opening of the glottis may be so far closed as to necessitate tracheotomy, and the use of a tube for the remainder of life. The symptoms and treatment are more fully described with Diseases of the Larynx, Vol. II.

The *Nose* is often extensively affected in constitutional syphilis, especially in individuals who are addicted to drink or much exposed to changes of temperature, and who are unable to pay proper attention to their treatment. The mucous membrane becomes chronically thickened, and this is accompanied by discharge of blood and pus, coryza, and habitual snuffling. In other cases ulceration takes place, with a very fœtid odour of the breath, and the formation of thick crusts on the septum, or between this and the alæ. This ulceration is very persistent and troublesome, and usually requires mercurial treatment, with the local application of strong nitric acid, or of the acid nitrate of mercury, to arrest its progress. In many cases ulceration will rapidly proceed to destruction and perforation of the septum, or necrosis of the spongy bones, the vomer, and ethmoid; sometimes excavating the whole of the interior of the nose, hollowing it out into one great chasm. When this

happens, the nasal bones are usually flattened, broken down, or destroyed, the alæ and columna ulcerating away, so as to give rise to great disfigurement. In other cases the hard palate is affected, and perforation takes place into the mouth. Occasionally the disease extends to the bones of the base of the skull, and in this way may occasion impairment of vision, epilepsy, or death. Cerebral symptoms, however, do not necessarily occur when the base of the skull is implicated. In 1870 I removed the whole body of the sphenoid from the nasal cavity of a man who had never suffered from any disturbance of the cerebral functions.

The *Treatment* of these nasal affections must be conducted in accordance with general principles. In many cases mercurial fumigation is extremely useful, though as a rule iodide of potassium has more effect. Iodoform sniffed up the nose, either pure, or diluted with nitrate of bismuth or starch powder, is more efficient than any other application in neutralising the intolerable stench caused by syphilitic disease of the bones of the nose. The cavity must also be washed out twice a day by means of a nasal douche. The dead bone must be removed when loose. (See Diseases of the Nose, Vol. II.)

The mucous membrane of the *Rectum* is not unfrequently affected in syphilis. In the early stages of the disease mucous tubercles are common at the anus. Small superficial ulcers, similar to those on other mucous membranes, may also be met with. These are not, however, of serious importance. The tertiary affections of the rectum, on the other hand, are always serious and often fatal. They occur most frequently in women. Two conditions are usually met with together—fibroid induration of the coats of the gut and ulceration of the mucous membrane. Submucous gummata are very rare. The induration of the coats of the gut, as a rule, precedes the ulceration ; it commences as a fibroid overgrowth in the submucous tissue, starting from the region of the anus and extending upwards. The new tissue, as it develops, contracts like that of a scar, and thus the wall of the gut becomes indurated and the canal narrowed. In the later stages the fibroid growth extends into the muscular coat, and the peritoneal covering may be thickened and opaque. The thickening of the submucous tissue interferes with the proper vascular supply of the mucous membrane, and ulceration follows. The ulcers have a foul grey floor and slightly raised edges. They may slowly perforate the gut into the vagina or peritoneum ; but general peritonitis is rare, as from the slowness of the process firm adhesions to surrounding parts have usually formed before perforation takes place. (See Syphilitic Stricture of the Rectum, Vol. II.) As the induration of the coats of the gut at first causes but little inconvenience, the patient seldom comes under the care of the Surgeon till some ulceration has taken place. In some cases serpiginous ulceration may be the primary change; but these are certainly the less common.

4. **Syphilitic Iritis** usually occurs during the first year after infection and often in people who are otherwise strong and healthy. The ordinary symptoms of iritis, somewhat modified, characterize the affection. The patient complains of dimness of sight, pain in the eye, and often of very severe circumorbital or hemicranial pains. On examining the eye, the conjunctiva will be found to be slightly injected, and a zone of pink vessels to be seated in the sclerotic, close to the cornea ; the aqueous humour has lost its transparency, giving a muddy look to the eye, and the colour of the iris is altered.

The pupil is diminished in size and irregular in shape, usually angular towards the nasal side, and small yellowish or brownish nodules of lymph may be seen on the surface of the iris. If the case be left to itself, or be improperly treated, it may advance to disorganization of the globe, and to permanent loss of sight. The retina often becomes affected, and incurable blindness results.

The *Treatment* consists in local depletion by means of cupping and leeches to the temples, and the administration of mercury and opium internally, at the same time that atropine drops are put frequently into the eye. Most commonly, as the mouth becomes affected by the mercurial, the eye will clear, the lymph becoming absorbed, and the pupil regaining its normal shape and colour. In some cases, however, a chronic inflammation continues: here the best effects result from the administration of small doses of perchloride of mercury, with repeated blistering to the temples; and, in a later stage, soda and bark may advantageously be given.

Fig. 405.—Syphilitic Periostitis of Tibia, resulting in the formation of a Fusiform Node.

5. **Syphilitic Diseases of the Bones.**—The bones are liable to suffer both in the secondary and the tertiary stages of syphilis.

In the secondary stage aching pains in the bones are not uncommon. They are worse at night, and may be unaccompanied by any recognizable change of structure.

The characteristic bone diseases of syphilis are usually delayed till the tertiary stage, some two years or more after infection. By some Surgeons the graver forms are said to be the result of the administration of mercury, rather than of the syphilis for which the drug is given. This doctrine I believe to be entirely without foundation. That they are met with in syphilitic cases in which no mercury has been given, there can be no doubt. I have had under my care patients with extensive disease of the cranium and of the clavicle, whose syphilis had been treated throughout on the non-mercurial plan. One patient especially, a soldier from whom I removed portions of the cranium and of the clavicle for necrosis accompanying constitutional syphilis, had been treated in a military hospital without mercury. I have never seen or heard of mercury producing necrosis in any bones, except those of the jaws, when given for diseases other than syphilis. No doubt diseases of the bones are especially apt to occur when the patient's constitution has been broken down by any means; and an improperly conducted mercurial

course may have this result. They occur usually after the patient has passed through the whole course of the less severe syphilitic affections, such as those of the skin, mucous membrane, and throat. The affections of the bones, however, may in some cases declare themselves at the same time as the affections of the skin and mucous membranes. They occur more commonly amongst the poorer classes, especially those who are exposed to atmospheric vicissitudes, and chiefly in strumous constitutions.

The diseases to which the bones are liable as a consequence of syphilis are the following :—

Syphilitic Periostitis or Node.—This consists of a localized inflammation of the periosteum, usually affecting one bone only, but sometimes many. The inflammation is accompanied by exudation into and under the membrane; the exudation may be absorbed, and the part restored to its normal condition, but more commonly it is partly or entirely developed into new bone, and thus a permanent thickening may remain (Fig. 405). In the early stages the new bone is soft and spongy, and is sharply separated from the compact bone beneath, which, beyond some slight superficial rarefaction from enlargement of the Haversian canals, shows no sign of change. As time goes on, however, the new bone becomes more compact till at last it seems merely a part of the compact tissues which at the affected spot may be a little denser than natural. Nodes may occur on almost any of the bones; but they are most commonly met with on the tibia, the clavicle, or the bones of the forearm. They form elongated, uniform, elastic or hard swellings, usually tender on pressure, and generally but little painful during the day; but at night the aggravation of pain is peculiarly marked, and constitutes perhaps the most distressing symptom. They cause no redness of skin and have no tendency to suppurate.

Fig. 406.—Syphilitic Sclerosis of Tibia. Transverse section showing Medullary Canal almost obliterated by dense new bone.

Sclerosis of Bone.—This corresponds to the diffuse overgrowth of fibroid tissue in other parts. It usually affects one of the long bones or the cranium. The bones become increased in size and density. The new osseous tissue is formed on the surface from the periosteum, but does not show the distinct separation from the old so clearly noticed in the ordinary node; the growth is, moreover, not limited as in a node, but widely diffused as through the whole shaft of a long bone or throughout the vault of the skull. At the same time that new bone is formed on the surface a similar change may occur internally till the medullary canal becomes gradually filled with dense new bone (Fig. 406). The symptoms of this affection are merely the steady increase in size, with obscure aching pains, worse at night.

Gummata of Bone.—These never occur alone, but are always associated with the periosteal node or with sclerosis of the surrounding bone. They most commonly form superficially, and are at first indistinguishable from the ordinary node; in fact, as before pointed out, the gumma in its commencement is identical in its nature with the diffuse syphilitic overgrowth of fibroid tissue, differing merely in its localization and intensity and in its tendency to fatty

degeneration and softening. A subperiosteal gumma runs the ordinary course of such growths; if unrelieved by treatment it gradually increases in size, approaches the skin superficially, and extends into the bone beneath; finally, it softens, the skin gives way, the slough is discharged, and a deep ulcer is left, at the bottom of which spongy ulcerating bone is exposed. This forms the most common variety of *syphilitic caries*. In the cranium the gumma may completely perforate the bone, but more commonly it is associated with great sclerosis of the vault of the skull, the thickened bone being hollowed out and worm-eaten in parts corresponding to the situation of the gummata. Occasionally the gummata form on the internal aspect of the skull, and may give rise to cerebral symptoms. Gummata of bone form rounded flattened tumours, accompanied with aching pain usually worse at night. After a time they soften, and may then resemble abscesses. However soft they may become, they must on no account be opened, as absorption may take place even after distinct fluctuation is present.

Syphilitic Necrosis may arise in various ways. In the vault of the skull it is

Fig. 407.—Syphilitic Necrosis of Frontal Bone. The sequestrum, which has completely separated, has a worm-eaten surface, the result of the inflammation of the bone which preceded its death.

most commonly due to an exaggeration of the process of sclerosis, by which the Haversian canals become obliterated to such an extent that death of the bone follows. The sequestra thus formed are often of considerable size, sometimes reaching that of the palm of the hand (Fig. 407). They are composed of dense hard bone, much thicker than the normal skull, and always more or less worm-eaten on the surface. This appearance is due to the previous existence of subperiosteal gummata which have softened and been thrown off. The skin of the scalp having been implicated in the gummata is destroyed partly by their softening and partly by subsequent ulceration, so that the surface of the sequestrum is usually bare and exposed. The process of separation is very slow, often lasting many years. Cerebral symptoms may be present, but are quite as often absent. Necrosis of the bones of the base of the skull may arise in the same way, or may result from ulceration of the mucous membrane of the nasal cavity or pharynx by which they are in many parts thinly covered. The tertiary ulcerations in the mouth and nose also may be

followed by necrosis of the hard palate, of the turbinate and ethmoid bones; but it is a remarkable fact that the hard palate is not nearly so frequently affected as the nasal and spongy bones. In consequence of this destruction of bony tissue, the nose may fall in, or a communication may be established between the nose and the mouth through the hard palate. Syphilitic necrosis may also affect the alveolar processes of the jaws. It is very uncommon in the long bones.

Syphilitic Caries, or ulceration of bone, is most commonly the result of the softening of a periosteal gumma, but it may be due to the extension of a superficial ulcer to the bone in thinly covered parts. The caries is rarely uncomplicated; usually, the surrounding compact bone is sclerosed, or in the neighbourhood of the ulcer there may be a considerable formation of new bone

FIG. 408.—Syphilitic Caries of Frontal Bone. The surface of the bone is extensively worm-eaten and eroded. Above the right orbit there is a shallow depression which has resulted from the healing of a carious patch.

from the periosteum. In other cases the process is a combination of necrosis and ulceration; the sequestra being surrounded by a zone of ulceration extending a considerable distance from the dead bone and not closely limited to its edge, as in the process of separation of a single piece of dead bone. Syphilitic caries is most common in the skull (Fig. 408), but it is met with also in other parts. The upper part of the sternum is not an uncommon situation. It is also met with in the extremities. I have twice seen a peculiar form of caries of the cancellous tissue of the head of the tibia in old syphilitic cases. In both cases, which were very similar, the patients had been affected for a length of time with nodes of the tibia, as a consequence of long antecedent syphilitic taint. A chronic abscess eventually developed over the head of the bone, leading to a carious cavity. I exposed this and gouged the diseased bone away; it was peculiarly dry, light, and almost flocculent, if such a term can be

applied to bone. Both patients recovered well from the operation; but one of them, a female, died two years afterwards of epilepsy, consequent on syphilitic gummata of the dura mater.

Both in acquired and in hereditary syphilis the bones of the fingers and toes are sometimes attacked, giving rise to the condition known as *syphilitic dactylitis.* It most commonly assumes the form of gummatous periostitis, often followed by softening of the new tissue and necrosis of the phalanx. The affected bones are much enlarged.

From the foregoing description it will be seen that the diseases of bones due to syphilis are all modifications of the same process which characterizes the disease elsewhere in its tertiary stage, namely an overgrowth of the connective tissue. The new tissue accumulates in some places in such masses as to form a distinct tumour, the gumma, which being imperfectly supplied with blood tends to degenerate. The node and the uncomplicated sclerosis of bone form the simplest stage of the process; the formation of gummata is the next advance; necrosis is an accident due to exaggeration of the sclerosis, or to exposure of the bone from softening of the gummata, and caries results also from the latter condition. It is not surprising, therefore, that we meet with these various effects combined in every possible way; the gumma is always surrounded by periostitis with or without the formation of new bone, caries and necrosis occur mixed together, and new growth and destruction may go on side by side.

The *Constitutional Treatment* of syphilitic diseases of the bones is that already recommended for the tertiary stage of the disease. Mercury is admissible only if the patient is otherwise in good health. Usually the iodides of potassium or sodium give the desired relief when administered in sufficiently large doses. *Locally* the treatment varies with the form assumed by the disease. The simple node usually requires no local treatment. If it is very chronic and painful, blisters will almost always give relief. If these fail and the case proves very intractable, and especially if there is considerable formation of new bone, I have found the greatest advantage result from cutting down upon the enlarged, thickened, and tender bone, and by means of a Hey's saw making a deep cut into it about one and a half or two inches in length parallel to its axis, and down to the medullary canal. By this operation the tension is at once relieved, and the pain effectually and permanently removed. In syphilitic *necrosis* the necrosed bone should be separated as it becomes loose; the local irritation depending on its presence then subsides. When the bone has fallen into a *carious* state, the unhealthy surface should be thoroughly scraped with a sharp spoon, and the cavity dressed with iodoform or iodide of starch ointment.

Syphilitic disease of **Joints** is not of very frequent occurrence. Pains in the joints are not uncommon during the very earliest stages, before the appearance of the eruptions; and during the secondary stage some slight synovitis has occasionally been observed, apparently due to the disease, but these conditions are of no great importance. Jonathan Hutchinson, Jun., has paid much attention to this subject, and has collected many recorded cases of joint disease in tertiary syphilis.

Any of the larger joints may be affected, but the knees are most frequently diseased. Gummata may form in the synovial membrane, capsule, or surrounding structures, whilst in other cases the synovial membrane undergoes

uniform thickening. In either case there is likely to be considerable subacute or chronic effusion into the joint, and this may occur without any other signs of disease. Periosteal thickening of the articular ends of the bones may occur. These joint affections are usually accompanied by considerable nocturnal pain, but a painless chronic synovitis may be met with. Complete cure may follow suitable treatment, but a varying amount of stiffness of the joint often remains.

Gummatous infiltration of the **Bursæ** is an occasional symptom of tertiary syphilis. In a case recently in University College Hospital considerable solid enlargement of each bursa patellæ was present in a woman whose palate showed unmistakeable evidence of old syphilitic ulceration. The swellings completely disappeared after a course of iodide of potassium.

7. Syphilitic disease of the **Muscles** and **Tendons** has been described by Bouisson and others. These structures are not unfrequently affected, but less often than the bones. In the muscles diffuse sclerosis has been described, but it is exceedingly rare. Gummata are much more common; they form ill-defined tumours in the substance of the muscle, growing slowly, with some aching pain and tenderness. They are less prone to soften than similar growths in more superficial structures. Elongated tumours resembling nodes have been described as affecting the tendons, and gummata are occasionally observed in their substance. They resemble similar growths elsewhere, and are best treated by iodide of potassium.

8. **Syphilitic disease of the Testicle.**—This assumes two forms—the diffuse overgrowth of the intertubular connective tissue, and the formation of gummata. These diseases affect the body of the gland, and are always met with as tertiary phenomena. The symptoms, pathological appearances, and treatment, are fully described with Diseases of the Testicle, Vol. II.

9. **Syphilitic Ovaritis** is a disease that I believe I have on several occasions met with. The history of the cases has been uniformly as follows: an attack of syphilis long before; various constitutional symptoms running through secondary and tertiary stages; inflammatory congestion of one ovary, as determined by vaginal and rectal exploration; eventual cure by means of leeching and the perchloride of mercury and bark or iodide of potassium—in fact, a condition of things closely resembling what occurs in syphilitic disease of the testicle.

10. **Visceral Syphilis.**—Our knowledge of the syphilitic diseases of internal organs is of modern origin. "Visceral Syphilis" was not only unknown to, but unsuspected by, so acute an observer as John Hunter, and the syphilographers of the early part of this century make no mention of it. To Dittrich, Lancereaux, Wilks, Bristowe, and Moxon we are indebted for the establishment of the fact that, after external manifestations of syphilis have in a great measure, if not entirely, disappeared, and the disease has entered its tertiary stage, gummata may form in most, if not in all, the internal organs, producing serious functional disturbance, and leading to organic changes of the most extensive and fatal character.

It may now be taken as a fact incontestably established by numerous pathological observations, that there are few, if any, organs that escape the ravages of syphilis; and although there may be a doubt whether some of the forms of disease met with in certain organs, as the liver, lungs, and spleen, and described as syphilitic, may not in reality be due to non-specific disease, to which, as well

as syphilis, they are common, there can be no doubt of the fact, that when gummata are met with in internal organs, the syphilitic nature of the disease is established.

The general pathological characters of the changes in the viscera and in the arteries have already been described (p. 1132). The complete description of the visceral affections belongs to Medicine rather than to Surgery, and it will be sufficient here briefly to indicate their nature.

In the *heart*, syphilitic growths have been found on the endocardium, less frequently in the valves; and two forms of myocarditis of syphilitic origin—one circumscribed, the other diffuse—have been described by Lancereaux.

The *lungs*, *liver*, and *spleen* are all liable to syphilitic growths. As a general rule, these may appear under two forms—either as gummata or as a diffuse interstitial growth, which in the liver may simulate cirrhosis, and in the lungs some of the forms of "fibroid phthisis." These syphilitic visceral diseases not unfrequently run a fatal course; rarely, however, destroying the patient before the age of 35 (Wilks). The diagnosis of the specific nature of the affection must always be open to doubt, except in those cases in which the history of the infection has been continuous, and some of the more superficial and easily recognizable syphilitic affections are associated with the visceral forms of the disease. So far as treatment is concerned, our chief reliance must be placed on iodide of potassium, or if that fail, on the careful administration of mercury.

11. Syphilitic disease of the **Mamma** is of extreme rarity, and little is definitely known about it. Gummata have been described by Hennig as having been observed after death in one case.

12. There is no more distressing form of syphilitic disease than that which affects the **Nervous System.** The brain and spinal cord and their meninges, and the trunks of the nerves, are all liable to suffer.

Syphilitic affections of the nervous system have been described as occurring during the first year after infection, but such cases are of extreme rarity; as a rule they do not manifest themselves till after the end of the second year, and they may appear as late as the tenth, or, it is said, even the twentieth. They occur at all ages, and are not uncommon in young men. I have often seen syphilitic disease of the nervous system about the age of 25 or 30. It is the common cause of paralysis in early manhood. The development of the symptoms may follow some slight accident—a fall upon or a strain of the back, or over-exertion in walking, riding, or running. The primary disease has often been slight, the secondary symptoms trivial; and indeed no great importance may have been attached to the venereal infection until the manifestations of its destructive effects on the brain and cord. In other cases the patient may be suffering, at the time of the appearance of the nervous symptoms, from severe tertiary affections, such as ecthyma, rupia, serpiginous or sloughing ulceration of the throat, or painful nodes on the cranium, vertebral column, or long bones. Habitual excess in alcoholic stimulants forms a powerful predisposing cause of syphilitic disease of the nervous system.

The pathological changes in the nervous system are of the same character as those in other parts of the body. They consist of chronic inflammation, with thickening of the meninges; overgrowth and induration of the interstitial tissue of the nervous centres and nerves; the formation of gummata; and the obstructive changes in the arteries already described (p. 1132). Certain chronic

degenerative diseases of the cord, especially sclerosis of the posterior columns (locomotor ataxy), follow syphilis with sufficient frequency to justify the belief that the disease may stand in some causal relation to them.

Syphilitic disease of the brain declares itself by two chief symptoms, which may occur either separately or conjoined; viz., paralysis and epileptic convulsions. Before these definite signs manifest themselves, various premonitory symptoms may have existed. The most common is severe pain in the head, usually fixed in one spot, often worse at night; there may also be some mental disturbance and want of sleep.

Paralysis from syphilitic disease of the brain usually assumes the form of hemiplegia. It may be preceded by paresis of special parts, as of one limb or group of muscles, which may be temporary in its character. The nerves of sensation may also be affected. Special cranial nerves may suffer. The third, fourth, sixth, and seventh are often early attacked, giving rise to ptosis, strabismus, or facial palsy. I have never seen the fifth nerve paralysed in syphilis, but cases have been recorded in which it was affected. Oculo-motor paralysis in some form, on the other hand, is very frequently the result of syphilis, and when it occurs in young men it should, however passing and slight, always attract the most serious attention, as it is often the precursor of more general paralysis. The early affection of the nerves that lie in the wall of the cavernous sinus is probably due rather to syphilitic thickening of the dura mater, with which they are in such close relation, than to an affection of the substance of the brain.

If the patient be hemiplegic, he may be completely so, but very often the paralysis is limited to one limb, or may be irregular in its degree in different parts. It is often accompanied by rigidity. These differences are due to the situation of the disease in the brain. Gummata in the dura mater or bone in the region of the cortical motor centres may cause irregular paresis or complete paralysis of the parts corresponding to the affected centre. Syphilitic growths in the deeper parts of the brain may give rise to complete hemiplegia, coming on gradually, and occlusion of a cerebral artery affected with the changes already described as occurring in syphilis may lead to the same symptoms being developed suddenly. Aneurisms of the cerebral arteries, ending in rupture with the ordinary signs of apoplexy, may also occur as the consequence of syphilis.

Optic neuritis is very common in syphilitic disease of the brain, especially in cases of very chronic meningitis, or when gummata are present.

Epileptic seizures are common in syphilitic affections of the brain. They generally result from chronic thickening of the dura mater, or the development of gummata in the membranes or substance of the brain in the region of the cortical motor centres. Gowers states that they "differ from the ordinary convulsions of epilepsy, especially when the motor zone of the cortex is diseased, in the deliberate onset of at least some of the attacks; in consciousness being lost late, and in the patient being aware of the local onset of the convulsions in the face, hand, or foot. In other cases, probably when the sensory rather than the motor region is diseased, a sensory aura, often involving the special senses, may herald the fit." According to Gowers, syphilitic epilepsy is recognized by its appearing usually at an age when the idiopathic disease seldom commences, by the headache between the fits, by the coincidence of optic neuritis, and often of local paralytic symptoms, and by the early and

often progressive mental disturbance. The fits are often of a very violent character, and followed by coma. But dangerous as these attacks may become, there is always a prospect of cure by proper treatment, although in some cases the fits may persist even after there is every reason to believe that the syphilitic growth which originated them has been absorbed. In other cases again, the mental powers undergo gradual deterioration, delusions manifest themselves, and the patient falls into a state of semi-imbecility.

There is no more pitiable object to be seen than a man, young or in the prime of life, suffering from syphilitic disease of the nervous centres—affected by ptosis, with one eye staring and immovable or squinting, the face distorted, the lip dropped and saliva dribbling, defective in his articulation, straddling and insecure in his walk, dragging one leg behind him, at times the victim of the most severe epileptic paroxysms, often covered with rupial sores—he is truly a fit object for commiseration rather than reproach.

Syphilitic disease of the Spinal Cord.—The most common syphilitic lesions of the cord are chronic meningitis and the development of gummata, which arise most frequently in the membranes, but sometimes originate in the substance of the cord itself. The gummata are usually small, rarely exceeding half an inch in diameter, though Wilks has recorded a case in which the tumour reached the size of a large filbert. Most commonly only one gumma is met with, but cases have been described in which numerous small tumours the size of millet-seeds were present. When the disease assumes the form of meningitis, there is usually considerable thickening of the dura mater, but the other membranes also may suffer, and the superficial parts of the cord be implicated. The roots of the nerves are compressed as they pass through the thickened membranes. The disease may be widely diffused, but is more commonly limited in extent, the region of the lumbar enlargement being specially prone to be affected.

Syphilis may also be the cause of disseminated chronic myelitis, leading to sclerosis, and Gowers has brought forward a large amount of evidence to show that locomotor ataxy (sclerosis of the posterior columns) may have its origin in this way ; about one-half of the cases of this disease occur in patients who have suffered from constitutional syphilis.

The *Symptoms* of syphilitic disease of the cord come on gradually. There is pain either in the back opposite the seat of disease, or referred to the parts supplied by the nerves arising from the affected portion of the cord. Various affections of sensation are commonly met with ; there may be numbness, tingling or "pins and needles," or localized spots of hyperæsthesia or anæsthesia. Paralysis of one limb or a part of a limb, or complete paraplegia, may form a prominent symptom. Wasting occurs only in those muscles which are paralysed in consequence of damage to the part of the cord from which their nervous supply is derived, or of pressure on the roots of the nerves. Thus, although there may be complete paraplegia, the wasting may affect only certain groups of muscles. The reflex function of the cord is abolished in the diseased part, but lower down it may be increased ; thus in disease in the dorsal region there may be exaggerated reflex movements in the lower limbs. Rigidity of muscles is common, spasm comparatively rare. When the paralysis is unilateral, the modifications of sensation will be on the same side as those of motion when the roots of the nerves are affected, but on the opposite side when the condition is due to the growth of a localized tumour,

either in the substance of the cord or in its membranes. The symptoms may be rendered very irregular and complex by the co-existence of various lesions, such as irregular patches of chronic meningitis, or a gumma combined with meningitis, or more than one gumma in different parts of the cord ; and this irregularity of the symptoms may be still further increased by simultaneous disease of the brain and its membranes. The age of the patient, the history of syphilis, and the irregularity of the symptoms often render the diagnosis comparatively easy.

The *Nerves* are comparatively seldom affected, though gummata have been met with growing from the connective tissue forming their sheaths. These have been observed almost exclusively in the cranial nerves.

In the *Treatment* of syphilitic disease of the central nervous system, if not too far advanced, there is fortunately much to be done for the patient's relief, if not complete cure. Mercury in some form, more especially the perchloride with decoction of cinchona, if not previously fully used, should have a fair trial. Iodide of potassium in gradually increasing doses—up to fifteen or twenty grains, three times a day, if the patient can stand it—should be given at once in those cases in which the patient has already had a full course of mercury, or in which the constitutional state does not justify the administration of mercury at the time the nervous symptoms set in. Counter-irritation by means of blisters will occasionally be found useful. The epileptic convulsions may be relieved by bromide of potassium or of ammonium, but these must not be given to the exclusion of the iodides. Under this treatment cases at first apparently hopeless may rapidly recover, but when the disease is far advanced, with the formation of gummata of large size, the prognosis becomes very bad.

INFANTILE, CONGENITAL, OR INHERITED SYPHILIS.

Chancres on the labia of the mother may possibly infect the child at birth, just as they may inoculate the hand of the accoucheur ; but syphilis thus contracted by the infant is not the form of the disease that is described as **Infantile Syphilis.** This is a truly hereditary infection, transmitted to the infant at the time of its conception, or communicated to it through the medium of the mother during intra-uterine life, and existing as a constitutional affection at the time of its birth. Though we may believe that syphilis is not easily eradicated from a system into which it has once been received, and that under certain conditions it may readily be transmitted to the offspring, yet I think that we are still ignorant of the amount and nature of the constitutional affection of the parents that are necessary for the development of syphilis in their children, and that we are certainly not warranted in concluding that a parent who has been, or even who is actually affected by constitutional syphilis, must necessarily have a syphilitic family ; although the probability undoubtedly is that the offspring will be affected. I have had under my observation a gentleman whom I had attended for secondary syphilis, and who, contrary to my advice, married some years ago ; and, though he has since then suffered from psoriasis of the hands, mucous tubercles, fissures on the lips and tongue, and syphilitic disease of the testicle, yet his wife has borne a perfectly healthy family, not only without any syphilitic taint, but without any apparent constitutional cachexy.

When the parents are syphilitic, the fœtus frequently fails to arrive at maturity. This may be due to disease of the placenta, or of the umbilical cord, or to the direct action of the syphilitic virus on the fœtus itself. In the placenta extravasations of blood, fatty degeneration, and the formation of caseous, and occasionally of calcareous masses, are the most common abnormal conditions observed. In the cord the vessels are occasionally found to have undergone changes identical in character with those already described as taking place in the arteries of the adult (p. 1132). The fœtus itself also shows evidence of disease in the great majority of cases in which it perishes before arriving at maturity, or is born dead at the full time. Mewis states that an examination of ninety-two syphilitic fœtuses showed the spleen to be diseased in seventy-two, the bones in sixty-four, the liver in fifty-six, the pancreas in fourteen, the suprarenal bodies in eleven, the lungs in three, and the skin in one only. In consequence of these diseases of the placenta and the fœtus, it often happens that early abortion or miscarriage takes place. Many consecutive miscarriages may take place in consequence of the parents being affected with constitutional syphilis. It is a common history in these cases that the period at which miscarriage takes place becomes later in each succeeding pregnancy, until at last, perhaps after a dead fœtus has been delivered at full term, a living child may be born bearing evidence of inherited syphilis. Such a history is very characteristic of syphilis, even if the parents have ceased to show any visible signs of the disease. When the parents are known to be syphilitic, if they be treated by a mercurial course, miscarriage can frequently be prevented, though the child may show some signs of the disease.

The offspring of syphilitic parents as a rule develop symptoms resembling in most points the acquired form of the disease. It is not impossible, however, that the taint may manifest itself by an impaired state of the constitution, and that syphilis may thus be a predisposing cause of scrofula or rickets. There is, however, no satisfactory evidence that this is the case.

The **Period at which the Symptoms manifest themselves** varies greatly. As a rule, a syphilitic child when born alive, though often small, badly developed, and cachectic in its appearance, shows no definite manifestations of the disease; but in the course of a few weeks, usually from two to eight, the symptoms declare themselves. Diday and De Méric collected a large number of cases, in most of which the signs of the disease developed in the fifth or sixth week. Many betrayed their disorder in the first month; and in some few it was delayed until the child had attained the age of three months. The earlier the disease shows itself, the more fatal are its effects. Children who manifest no symptoms till they are two or three months old usually recover their health in a short time.

The effects of inherited syphilis may also manifest themselves even in adult age. Hutchinson believes that this may take place without any signs of syphilis during infancy; this view, however, is not entertained by Berkeley Hill, and most other writers on the disease. They assert that though they may have been slight, some symptoms have in every case been present during the early months of life. These cases are rare, and the following which fell under my own observation is a good instance. The patient was a young woman, aged seventeen, who was covered with a marked squamous syphilide, with which she had been affected for several years. The mother told me

that, shortly after birth, evidences of infantile syphilis had appeared; that these had yielded to treatment, but that, as the period of puberty approached, the rash, which was undoubtedly syphilitic, had shown itself.

Symptoms.—The symptoms of inherited syphilis are sufficiently well marked in most cases, consisting principally of general constitutional disturbance, with affections of the skin, mucous membranes, bones, viscera, and eye, which more or less closely resemble the manifestations of acquired syphilis.

Constitutional Symptoms.—The first indication is often the atrophic and cachectic appearance of the child; this not unfrequently shows itself at birth, without any more definite signs of the disease. Such children are often small, shrivelled, wan and wasted when born; the face especially has an aged look, the features being pinched, the flesh soft and flabby, and the skin loose and wrinkled; the complexion has a yellowish or earthy tinge, which has been compared to that of *café au lait*. These appearances are, however, by no means always present. Many syphilitic children are born apparently healthy and fat; but they soon emaciate when the cutaneous and other manifestations of the disease make their appearance a few weeks after birth. In slight cases, however, the child may remain fat and well-nourished, though anæmic, throughout the whole course of the symptoms.

Local Symptoms.—In the great majority of cases the most marked symptoms are due to the affections of the skin and mucous membranes. As in acquired syphilis the first appearance may be a roseolous eruption on the skin, but this is of short duration, and seldom clearly marked. The earliest marked feature is usually the appearance of *mucous tubercles*. These form at the angles of the lips, in the cavity of the mouth, in the pharynx, in the nose, at the anus, and wherever the skin is moist, as in the folds of the groin, and between the scrotum and thigh. They are of the same nature and appearance as those met with in acquired syphilis.

The affection of the **nose** is amongst the most constant and characteristic features of the disease, and is usually the earliest local sign that declares itself. There is much congestive swelling of the mucous membrane, with a secretion of thick yellow offensive mucus, causing the child to make a peculiar snuffling noise in breathing, as if it had a chronic catarrh. This symptom is so constant that it has given rise to the popular name of "the snuffles" which is applied to congenital syphilis. The degree to which the nose is affected varies considerably. In the mildest cases the symptoms merely resemble those of a slight cold; in the most extreme forms the discharge dries into scabs at the nostrils, beneath which ulcers may form; mucous tubercles develop on the membrane, and ulceration may follow, leading to disease of the bones, with flattening of the bridge of the nose. In all cases free breathing through the nose is interfered with, sucking consequently becomes difficult, and the trouble in feeding the child is correspondingly increased.

The **mouth** is similarly affected, but usually in a less degree. Radiating fissures, sometimes extending somewhat deeply, are common on the lips, especially at the angles of the mouth. The mucous membrane of the cheeks and tongue is covered with mucous patches, and sometimes with superficial ulcers.

The mucous membrane of the **larynx** is congested and swollen in most cases, and sometimes mucous tubercles may be formed at the opening of the glottis. The laryngeal affection is the cause of the hoarse cry which usually forms a marked feature in the disease.

The **Eruptions on the Skin** are usually most abundant on the nates, scrotum, and the soles of the feet; hence in examining a child supposed to be syphilitic these parts should always be looked at first. In moist situations the eruptions most frequently assume the form of smooth, flat mucous tubercles, varying in size from a pea to a threepenny-piece; they are slightly elevated, and covered with a slimy whitish secretion. Cracks or fissures are common at the anus as well as at the mouth. In the drier parts the eruption is often described as *squamous,* though it is not really scaly, but composed of smooth flat patches of a coppery red colour. These patches are often well-marked on the soles of the feet, and are followed by peeling of the cuticle.

A diffuse *erythematous* eruption is perhaps the most common, and may be difficult to distinguish from the simple intertrigo which is so common in infants about the nates as the result of irritation of urine, &c. The syphilitic eruption, however, often spreads to the calves and soles and upwards on to the back, and the rash is more uniform and confluent than is usually seen in the simple intertrigo.

Papular eruptions are not common. The *bullous* eruption, or so-called syphilitic pemphigus, is less common than those first mentioned, yet I have frequently seen it in syphilitic children. It appears in the form of vesicles which enlarge into bullæ about the size of a split pea, with a dusky coppery areola; they dry into brown scales or scabs, and commonly occur simultaneously with mucous tubercles in other parts of the body. The eruption is almost invariably present on the soles and palms; it appears early, and may be present at birth. The prognosis in all cases of bullous syphilide is very grave. The eruption has to be distinguished from the simple pemphigus which occurs in non-syphilitic children; this is probably a septic rash, and, unlike the bullous syphilide, never appears on the soles of the feet.

A *pustular* eruption is also occasionally met with. The pustules dry early, leaving a black scab, beneath which ulceration may take place. It is met with only in very feeble children.

Subcutaneous gummata are met with occasionally in inherited syphilis, but seldom before the second year.

The *Hair* very commonly is thin, and is often lost from the posterior and lateral aspects of the head. The *Nails* are seldom affected, but may be brittle and grow irregularly.

When we consider the influence exercised by the syphilitic poison upon the skin and its appendages, the hair and nails, we should *a priori* have expected that the **teeth**, being developed from the same embryonic layer, would participate in the morbid processes induced by it in the allied structures. The fact of their doing so does not, however, appear to have attracted the notice of any observer, until Hutchinson directed the attention of the profession to this very interesting subject, and pointed out the destructive and special effect produced upon the teeth by inherited syphilis. This injurious influence manifests itself both in the temporary and in the permanent teeth; but it is characteristic only in the permanent set. It must not, however, be supposed that in all cases of infantile syphilis the teeth are affected; indeed, in many instances they are not, and it has been particularly pointed out by Hutchinson that it is only when there have been attacks of syphilitic stomatitis that we are to expect to meet with these abnormalities in the teeth.

The *temporary teeth* of syphilitic infants are cut early, are of bad colour,

and liable to a crumbling decay. The upper central incisors usually suffer early, and always first; then the lateral ones become carious and drop out; and lastly, in some cases, though rarely, the canines wear away so as to present a tusk-like appearance. In consequence of the early decay of the incisors, children are often edentulous, so far as these teeth are concerned, from an early age, until the permanent ones are cut.

The *permanent teeth* present the more marked characteristics of an inherited syphilitic taint; and in these, as in the temporary teeth, the disease declares itself chiefly in the central incisors of the upper jaw. These will be observed to be usually dwarfed, too short and too narrow, rounded at the angles, standing apart with interspaces or converging, and marked by a deep broad notch. They are of a bad colour, soft and crumbling, are slender, and readily wear down (Figs. 409—411). The characteristic features are the dwarfing and the central cleft in the free edge. In other cases the cutting edge of the incisor teeth is narrow, so that the teeth have a peculiar "pegged" shape.

Fig. 409.—Syphilitic Teeth in a boy aged 12 years.

Fig. 410.—Two Central Syphilitic Incisors Deeply Notched (Hutchinson).

Fig. 411.—One Central Incisor Notched (Hutchinson).

The upper alveolar border is often narrow and the arch of the palate unduly high.

The **Bones** are very frequently affected in congenital syphilis, though until recently the changes that take place had been partly overlooked and partly confounded with rickets. The observations of Wegner, Parrot, Barlow, and others, have, however, clearly established the fact that the implication of the bones is second in frequency only to that of the skin.

Parrot states that the affections of the bones in hereditary syphilis assume two principal forms, one consisting in atrophy of the pre-existing structures, and the other in the development of new tissue. The Atrophic form he divides into two varieties. The first, to which he applies the term *Gelatiniform*, affects equally the cranium and the bones of the extremities. The bone is altered in colour, varying from a pale red or rose tint to different shades of yellow. The medulla becomes transparent, and is at last reduced to a network composed of vessels and delicate fibrillæ, the meshes of which are filled with watery fluid. When the compact tissue is invaded it becomes rapidly

decalcified ; the lamellæ seem to melt away, and large spaces appear between them, filled with a gelatinous substance, like the altered medullary tissue. The second variety he terms *chondro-calcareous atrophy.* The most marked feature of this form is that the layer of calcified cartilage which naturally exists in the growing line between the shaft and the epiphysis assumes an abnormal thickness and loses all regularity in its outline. The calcified cartilage can be recognized by its density, brittleness, and chalky appearance. The formation of this brittle tissue renders the bone liable to fracture, and when the two forms of atrophy occur simultaneously this result is almost certain to take place. The fracture occurs always in close proximity to the epiphysis, and the accident is not unfrequently followed by suppuration, and from the close proximity to the joint suppurative arthritis may be set up. These fractures give rise to symptoms closely resembling paralysis of the affected limb, and Parrot has applied to the condition the name of *syphilitic pseudo-paralysis.* The limb hangs powerless, and, as a rule, there is singularly little pain, but the muscles respond readily to the faradic current. The looseness of the epiphysis can sometimes be readily recognized, and some fine grating crepitus may be present.

Fig. 412.—A tibia from a syphilitic child showing osteophytic growths.

The second form of disease of the bones in hereditary syphilis, to which Parrot applies the term *osteophytic*, is much more common. This also he divides into two varieties, according to the density of the new tissue. When this is hard and bony he terms it *osteoid;* when soft, *fibro-spongioid* or *rachitic.* The osteoid form of growth may be met with at any period of childhood, and possibly may commence before birth : the rachitic is never met with before the fifth or sixth month. The osteoid growth is composed of trabeculæ, arranged more or less perpendicularly to the surface of the bone, separated from each other by medullary tissue ; the new tissue contains large quantities of lime salts. It differs from normal bone in its brittleness and in its yellow or pink colour. In the rachitic form the new tissue is almost white, pearly, or yellowish in colour. It is fibroid in structure and very vascular. Various modifications between these two forms of tissue may be met with. Thus the osteoid tissue may be arranged in several layers, or spongy tissue may be found covering the harder tissue. The periosteum covering the new growth is always distinctly thickened, and adheres firmly to it. There is almost always a distinct line of demarcation between the new tissue and the healthy bone beneath. The thickness of the growth varies from one-tenth to three-eighths of an inch on the long bones, but it may exceed this on those of the skull. In extreme cases almost the whole skeleton may be affected, but more commonly the diseased condition is met with only in certain parts. The most common situations are the lower end of the humerus, the tibia, the femur, and the ulna, where, unless the child be very fat, it can often be recognized during life. In the rachitic form the long bones may undergo modifications in form from bending or fracture, as in rickets.

The bones of the **Skull** present changes of a very marked character. These most commonly consist of the formation of "bosses" of new bone, from the

outer table only, around the anterior fontanelle and along the line of the sagittal and interfrontal sutures. Between these bosses the sutures may at first form distinct sulci, but later on they are often bridged over, and premature union may take place. If the child dies the bosses will be found to be composed of soft bone, very red in tint, sometimes even of a dark maroon colour. If macerated the new bone is porous and granular in structure, and is often deeply grooved by vascular channels. There is little if any thickening of the periosteum. The anterior part of the skull may reach a third of an inch or more in thickness. The effect of these growths is to give the forehead the rounded prominent form which was pointed out by Hutchinson many years ago as being often associated with other signs of congenital syphilis in later life. Barlow and Lees have pointed out that the condition known as *cranio-tabes* is also met with in syphilitic infants, although it is by no means confined to them. In this the bones of the vault of the skull become extremely thin in circumscribed patches, so as to yield to gentle firm pressure, feeling like parchment beneath the finger. In some spots the bony material may entirely disappear, leaving only a thin membrane. These spots are most common in the occipital region, where the bone is exposed to direct pressure while the child is lying on its back, but they are also met with in the parietal bones. The bony growths are met with at any time during the first two years, but the irregularity they give rise to may be recognized at any age. Cranio-tabes occurs at an early period during the first year of life. Both conditions may occur in the same skull. In addition to the above diseases of the bones gummata are occasionally met with in the skull, and dactylitis, similar to that described as occurring in acquired syphilis, is not uncommon. Up to puberty chronic inflammation of various long bones, especially of the tibia, is occasionally met with in syphilitic subjects.

Attention was first especially drawn to an affection of the **Joints** in congenital syphilis by Clutton in 1886. It occurs usually between the ages of 8 and 15, and consists in a painless effusion into the knee-joints which is in some cases accompanied by thickening of the synovial membrane. It is not attended with any impairment of mobility. The synovitis is usually bilateral, although the affection rarely begins simultaneously in the two joints. It is interesting that the joint affection is frequently associated with the affection of the eyes to be next described: thus of 11 cases collected by Clutton, 10 were affected with active keratitis, and in 1 there was evidence of past mischief.

Under the name of **Chronic Interstitial Keratitis,** Hutchinson has described a disease which he believes to be uniformly due to hereditary syphilis. It occurs between the ages of 5 and 18, but may occur much earlier, even during the first year. It consists at first of a hazy condition of the cornea, giving it the appearance of ground glass, followed by vascularization, without any tendency to ulceration. The opacity commences in the centre, and both eyes are usually affected. The vascularity is not confined to the surface, but seems to pervade the whole thickness of the cornea. One eye is usually affected before the other. Under a carefully conducted course of mercurials and iodides, accompanied by tonics and good diet, the transparency of the cornea can usually be restored.

Chronic affections of the **Ear,** leading to deafness, are not uncommon in inherited syphilis. They occur sometimes in conjunction with interstitial keratitis in the eye. Their pathology is not yet certainly known.

The **lymphatic glands** show no special morbid conditions resulting from inherited syphilis. Affections of the **Viscera** in congenital syphilis are by no means uncommon. They assume the same forms as in the adult, namely, general fibroid induration of the affected organ and the formation of gummata, the former condition being the more common. The spleen in syphilitic children is in most cases somewhat enlarged and hard. The liver is affected next in order of frequency. Syphilitic disease of the lung is met with only in children born dead, or dying soon after birth.

The **testicles** occasionally present a uniform, smooth, hard, painless enlargement, affecting the body of the gland, and corresponding in every respect to the same disease in the adult.

The **nervous system** is less commonly affected, but gummata are occasionally met with in the brain.

Evidence of Congenital Syphilis in later childhood or adult life.— The taint of congenital syphilis may manifest itself after the period of infancy by various chronic inflammations of bone, by diseases of the eye, and occasionally of the viscera; and as these present, as a rule, no very definite signs of their origin, it is important to remember the points by which the nature of the case may be established. In the history we must inquire for miscarriages before the birth of the patient, for signs of syphilis in previous children born alive, and for symptoms of the disease in the parents, such as prolonged sore throat, eruptions on the skin, loss of hair, and pains in the bones. With regard to the patient, we must ask the period at which birth took place: the appearance at birth, whether fat or thin; the occurrence of snuffles and sores on the bottom. In examining the patient, we must look for stunted growth; a flat or ill-developed bridge to the nose; and radiating scars at the angles of the mouth. The forehead must be examined for bosses in the region of the anterior fontanelle, and the humerus, femur, and tibia should be searched for thickenings or want of symmetry in the two sides. The eye also should be examined for interstitial keratitis, and the teeth for the appearances already described. All these signs are seldom present together, but enough to enable the Surgeon to come to a correct conclusion will always be found in any case in which the disease has been sufficiently severe to affect the patient after early childhood.

Prognosis.—If the child is born with signs of syphilis, it usually dies. Emaciation increases, and death takes place either directly from the disease or in consequence of some complication, as diarrhœa, bronchitis, or pneumonia. If the child is born apparently fat and well, the prognosis depends much on the period at which the symptoms appear; the later the appearance, the better the prognosis. Most cases recover in which the symptoms do not manifest themselves till after the end of the first month.

TREATMENT.—The occurrence of syphilis in the infant may be *prevented* by putting the infected mother on a mercurial course as soon as her pregnancy is ascertained; this indeed may be necessary in order to prevent miscarriage, but should be done cautiously, and by inunction rather than by mercury administered by the mouth. Should repeated miscarriages have occurred, as the consequence of constitutional syphilis, one or other, or both of the parents, if both are at fault, should be put upon a mercurial course; and thus the recurrence of this accident may be prevented.

The **Curative Treatment** as regards the child is extremely simple. It

should be nursed by its mother, if she has sufficient milk and is in good health. If this be impossible, it should be brought up by hand, and must not be given to a wet-nurse, lest it infect her. (See p. 1122.) The child must then be put under the influence of mercury, which in these cases produces the most unmistakeable effects; indeed, the ready manner in which all disease may be eradicated from the system of a syphilitic child by this mineral, is perhaps one of the strongest proofs that can be adduced of the specific character of its action on the venereal poison. The mercury may be given by the mouth in the form of small doses of grey powder; but, as it often purges the child when administered in this way, Brodie recommended its introduction into the system by inunction, which process I invariably employ, and have found it a most successful mode of treating the disease. The most convenient plan is, as recommended by Brodie, to spread a drachm of mercurial ointment on the under part of a flannel roller stitched round the thigh just above the knee, and to renew this every day after the child has been well washed in a hot bath. The treatment should be continued until all rash and snuffling have disappeared, when, the mercury having been discontinued, the cure may be perfected by the administration of small doses of iodide of potassium in milk or cod-liver oil. The skin must be kept in a healthy state by a hot bath every day. Occasionally the cutaneous manifestations of infantile syphilis are complicated with, and obscured by, some of the common diseases of the skin incident to early childhood; more particularly with pustular eczema of the head, face, and body. In these circumstances the diagnosis may not be easy, though the history of the case, the concomitant appearance of two forms of the disease, and the existence of snuffling and cachexy, tend to establish it. The eruption also, in these circumstances, is browner and more squamous than usual. In cases such as these, the best plan is to treat the syphilitic affection with the mercurial inunction, and then to prescribe a mild course of the liq. arsenii et hydrargyri iodidi, one to two minims for a dose, keeping the child at the same time on a good nourishing diet.

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